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# THE INSTITUTION OF PRODUCTION ENGINEERS JOURNAL



DECEMBER 1959

# THE INSTITUTION OF
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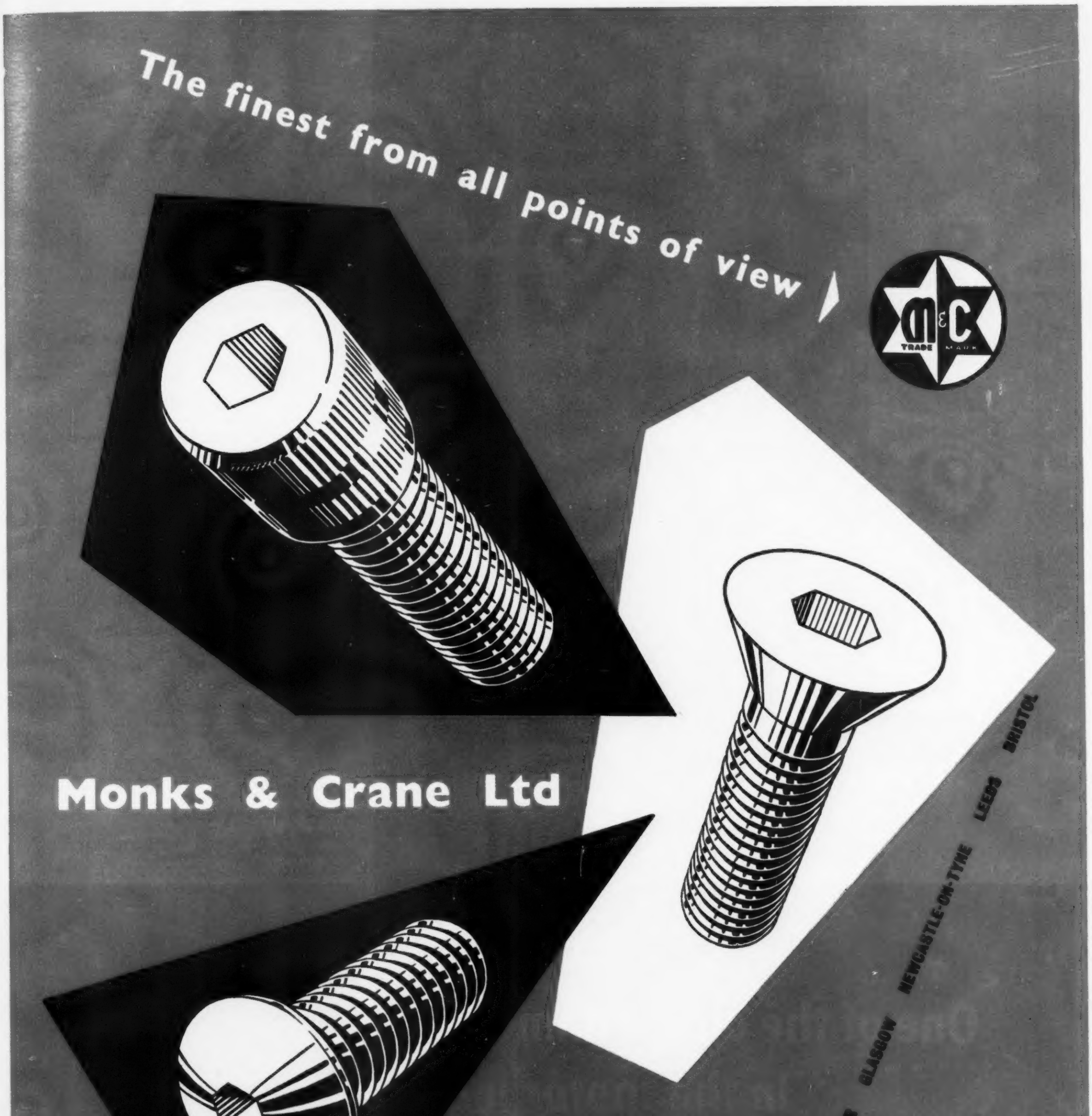


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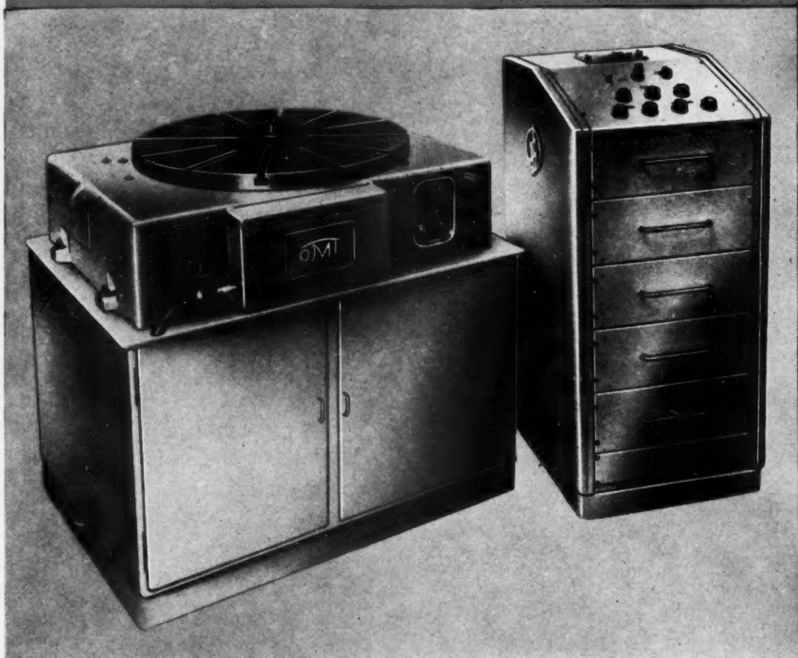

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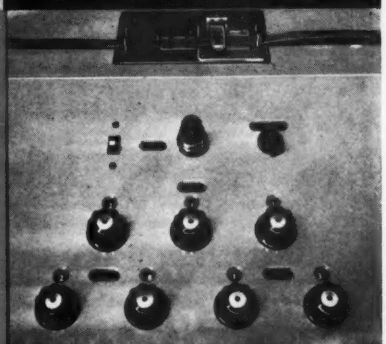

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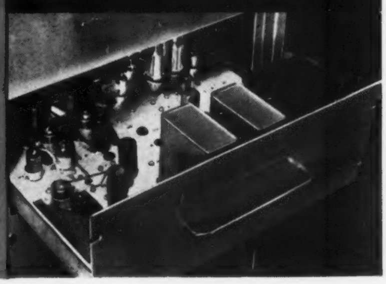

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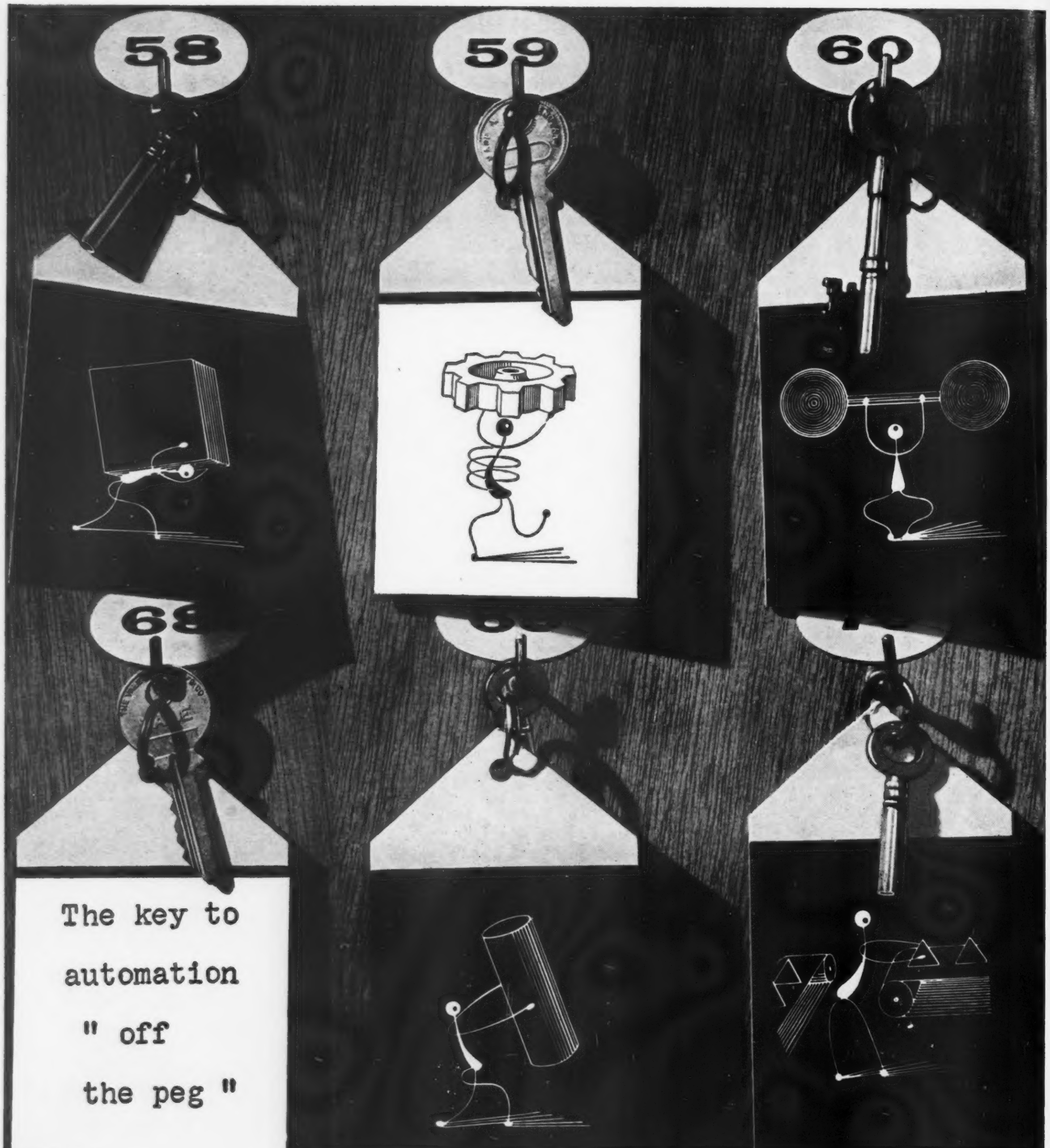




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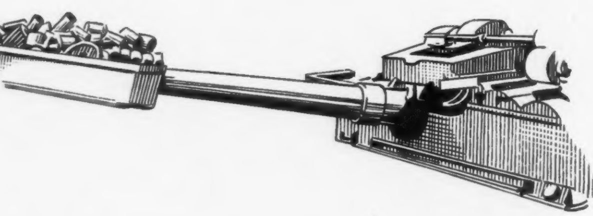

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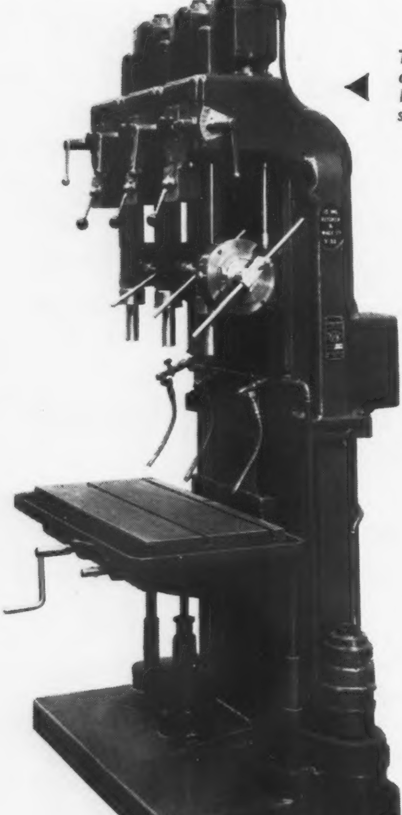

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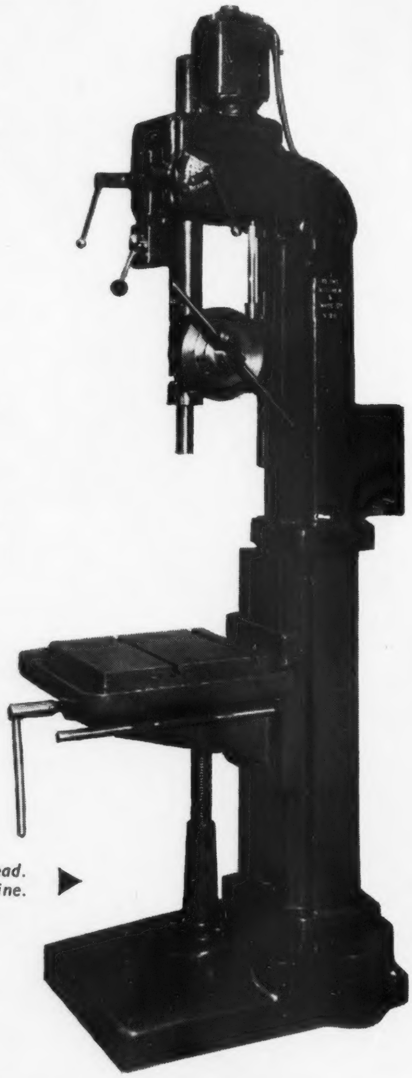

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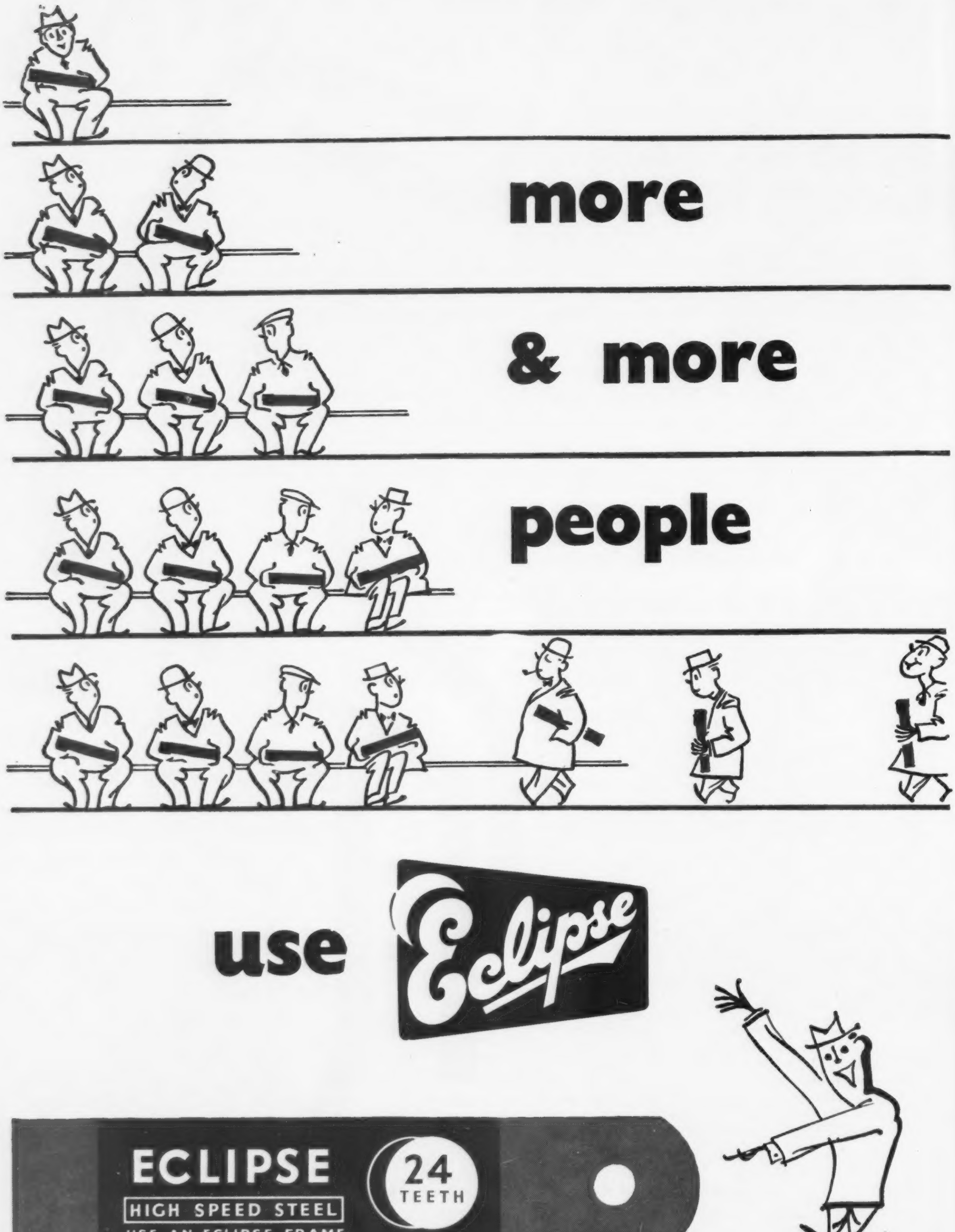
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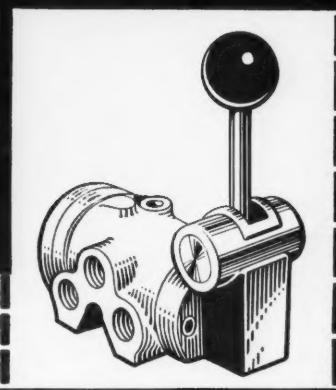

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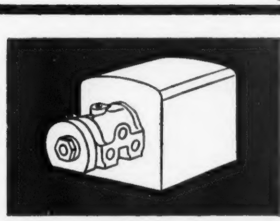

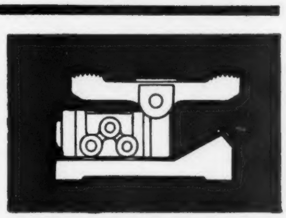

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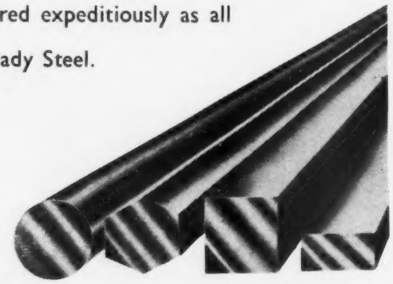

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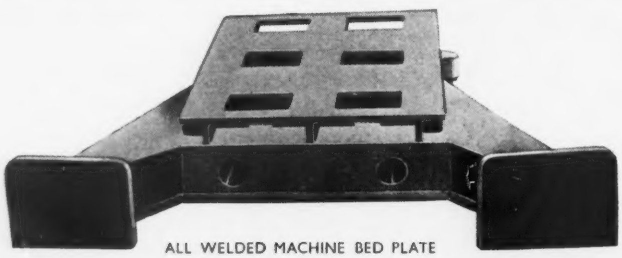

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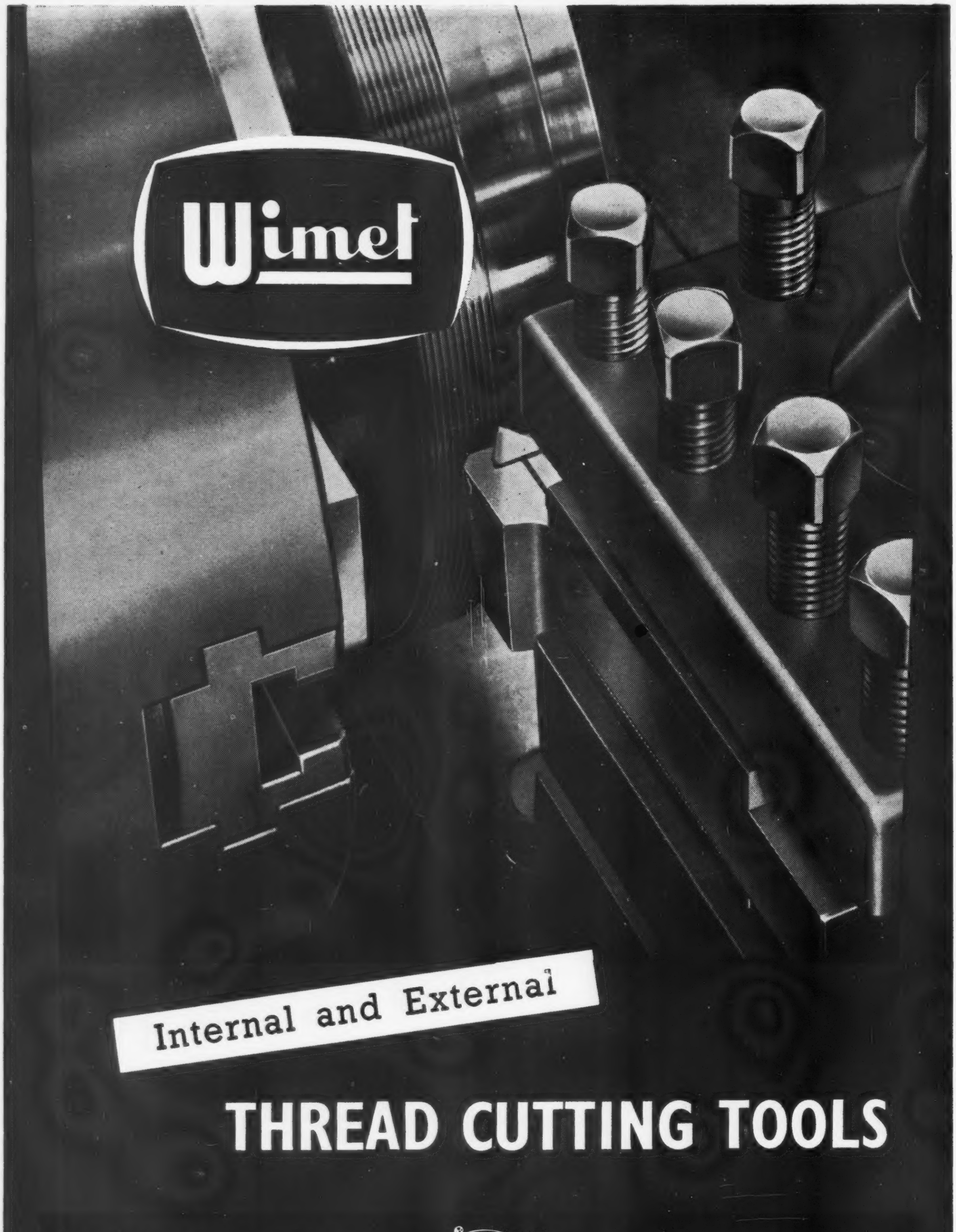
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The Institution of Production Engineers Journal
VOL. 38 NO. 12 DECEMBER, 1959

# A REPORT ON PRODUCTION ENGINEERING IN THE BRITISH UNIVERSITIES

by R. C. BREWER

Department of Mechanical Engineering,
Production Engineering Section,
Imperial College of Science and Technology.

IT is not many years since there were virtually no production engineering activities in any of the British universities. As this Report will shew, there is still room for expansion but the situation is considerably better than it was in the early post-war years.

No fixed terms of reference were given to the author and he decided to consider the universities only, taking a university to be an institution in receipt of a grant from the University Grants Committee and having the power to confer degrees. This decision has had the effect of eliminating from consideration such institutions as The College of Aeronautics and the Colleges of Advanced Technology, but it was felt that there were too many and too great differences between the universities and the other colleges to make a homogeneous report. Something could, perhaps, have been achieved by dividing the report into two parts, but the author felt that the Colleges of Advanced Technology would be better dealt with in a separate report by someone more intimately connected with their recent developments.

The Report of the Delft Conference[1] defines the purpose of a university in a manner with which few would quarrel — " the purpose . . . is the development of a student's ability to think logically, critically and constructively in relation to his chosen field of study; to acquire social interests and an appreciation of the broader field of facts and theories which may help him in later life . . .". What is more controversial is the stage at which a university student may commence to study production engineering and yet still satisfy the above definition. Some people hold that this stage does not occur in the undergraduate years at all, i.e., that production engineering is essentially a post-graduate study in a university. Others would have a degree in production engineering with a course divorced from mechanical engineering as soon as possible.

It is the object of this report to tell, as objectively as possible, how the various universities have reacted to production engineering as a university study. In this connection, consideration has been given under three headings :-

1. undergraduate courses; 2. post-graduate courses; 3. research.

In order to give all essential information and yet not to burden the main text with over-tedious detail, rather liberal use has been made of Appendices.

As far as possible, the author has avoided repetition of the Report of the Delft Conference which was concerned mainly with seeing how far university courses " could be matched with the present trends of production engineering education as seen by the Institution and as already practised in universities on the Continent " [1]. The present report is largely a factual presentation of the contemporary position of production engineering in the various British universities.

Universities vary not only in the number of their faculties but also in the nature of them. Several have no faculty of engineering and, of those which have, many have no production engineering activities. Such universities concern this report only in a negative way but, for completeness, they have been listed in Appendix A.

**undergraduate courses**

There is no bachelor's degree in Production Engineering in the strict sense of the word, i.e., there is no undergraduate course which is specifically designed to cater for production engineers from the commencement of the first year. This is not to say that an undergraduate course in Production Engineering must be completely divorced from Mechanical Engineering syllabuses, but it is not clear whether the practice of introducing Production Engineering as a bias to a mechanical degree is based on conviction that this is the correct method of solution, or simply that it is administratively convenient and, furthermore, evades what must be a most difficult policy decision, viz., whether there is a valid case for an undergraduate qualification devoted solely to Production Engineering.

The amount of emphasis placed on Production Engineering in undergraduate syllabuses varies considerably. Many universities do little more than provide compulsory or optional courses of lectures covering the basic technological aspects of production in a rather introductory, and necessarily superficial manner.

An instance of this is Manchester University, which offers Production Processes as an optional third year subject in the Ordinary course and has an arrangement with the Manchester College of Science and Technology whereby second-year students receive some lectures and practical work in Metrology. The University of Aberdeen includes only the subject "Engineering Materials and Measurements" in the first year of the ordinary degree. The University of Liverpool includes a subject called Workshop Technology in the first and second years of the B.Eng. course; this includes both lectures and practical work in metal cutting, foundry technology and metrology. University College, London, offers a half-course designated Production Engineering in the third year, but this course is coming up for review in the near future. At Imperial College, London, first-year students take the compulsory subject Mechanics of Manufacturing Processes and the treatment of production processes is completed, for many students, in the third year, where the first half of the optional course "Production Engineering" deals with machining and machine tools. The second half of this third year course is devoted to an introduction to Industrial Engineering, thus taking the course out of the realms of pure technology. A third-year student may also take, as an optional subject, a course in Management and Business Administration; this course is provided by the London School of Economics, which is one of Imperial's sister colleges in the University of London. Students at Queen Mary College, London, may also take optional subjects at the London School of Economics but it is proposed, next year, to make Economic Analysis a compulsory subject in Part II although Industrial Organisation will still be optional in Part III.

The University of Glasgow also goes outside the realm of production technology and provides, in addition to the lectures in Engineering Production, two additional lecture courses — one in Engineering Economics and the second in Industrial Psychology. Undergraduates may choose one or more of these subjects.

The University of Cambridge has three streams of students. One stream takes what is called the Engineering Studies course, this leading to an ordinary degree; this course and the honours course are common in the first year. In the second year of the Ordinary course there are lecture courses in Workshop Processes and Workshop Practice, while in the third year, there is a course on Industrial Administration and Economics. The other two streams are the "fast" and "normal" streams of the honours course. The "normal" men take Part I of the Mechanical Sciences Tripos after three years' residence. The "fast" men take Part I after two years, and can then take Part II of any Tripos in their final year. The majority, however, take Part II of the Mechanical Sciences Tripos, which, until recently, consisted solely of technological scientific subjects.

Earlier this year, proposals concerning an industrial management course[2] were accepted by the University. These proposals were for one year's course of lectures in the following subjects:-

1. Quantitative Analysis and Control
2. Human Behaviour in Industry
3. Industrial Organisation
4. Economics, Finance and Accounting
5. The Social Environment of Industry

The course and examinations are available to candidates holding Part I of either the Mechanical Sciences or Natural Sciences Tripos, Part II of the Mathematical Tripos, or Part I of the Mathematical Tripos together with one part of any other Tripos. Thus, the course could be regarded as post-graduate or undergraduate; it aims to give some insight into the fundamentals of the fields of knowledge which underlie the process of management.

At the Part I level of the Mechanical Sciences Tripos, a series of six lectures on Measurement is given in the first year "fast" and second year "normal" course, and the lectures on Workshop Processes (mentioned in connection with the ordinary degree) are given in the second year "fast" and third year "normal" courses.

A degree in Production Engineering has been approved, in principle, by the University of Nottingham. For some time, there has been a Professor of Industrial Economics and lectures on Industrial Administration have been given by members of his staff to Mining and Engineering undergraduates. The appointment earlier this year, of Dr. W. B. Heginbotham to the Senior Lectureship in Production Engineering, now enables progress to

be made on the technological side and a start is being made, this academic year, with the introduction of some production subjects.

Let us turn now to the universities which provide a definite bias towards Production Engineering. One of the oldest established of such courses is that at The Manchester College of Science and Technology. All students take Workshop Technology in the first and second years and Works Organisation in the second year. There is a special third year honours course for Production Engineering, some of the lectures being also taken by the third year ordinary students. The subjects available are set out in Appendix B.

The course at King's College, Newcastle (University of Durham) follows a similar pattern, inasmuch as it is the third year before any special subjects are provided for the Production Engineers. Details of this course are also shewn in Appendix B.

Although there is no specific provision for the granting of the B.Eng. in Production Engineering, the University of Sheffield offers several relevant courses. Engineering Manufacture is taken in each of the three years and is very broad in conception, including Metrology, Applied Statistics, Production Processes, Machine Tools, Jig and Tool Design, Metallurgy and a syllabus comparable to the former third section of the Institution's Associate Membership examination. In addition, there is a course in Metallurgy in the first year and a course in Economics, Accounting and Law in the third year. This latter has replaced the former subject "Engineering Economy and Management" as from October of this year.

The Heriot-Watt College, Edinburgh has recently introduced new regulations which have increased the duration of the course from three to four years. The subjects Workshop Technology (second year), Principles of Engineering Production (third year) and Engineering Production (fourth year) cover the technological side. Industrial Administration is taken in both third and fourth years and Work Study in the fourth year only. In accordance with the modern trend, there is also a fourth year subject, "Instrumentation and Automatic Control".

At the University of Leeds all mechanical engineering students must take either Industrial Management or Industrial Relations in the second and third years; the lectures for these subjects are given in the Department of Economics. A more definite bias to Production Engineering is available by means of the subjects Production Engineering in the second year and Engineering Production and Administration in the third year. Since the titles of these subjects are somewhat vague, further details have been given in Appendix C.

The Royal College of Science and Technology, Glasgow, at present offers a class in Production Engineering which is intended to give students taking a Mechanical Engineering degree, exemption from Section III of the Associate Membership examination of the Institution of Mechanical Engineers, but plans are being prepared to bring a higher proportion of Production Engineering into the Mechanical Engineering course. There is also a possibility that an Associateship course in Production Engineering may be offered.

**post-graduate courses**

As mentioned previously, there is a sharp division of opinion concerning the desirability of teaching production engineering at undergraduate level. There are those who think that production engineering has no place in the training of university undergraduates, those who feel that a fairly superficial treatment of the technological side may be given (though possibly only to the "weaker brethren" on an ordinary course) and, finally, those who approve of a much wider introduction of production engineering, either as a special degree or a pronounced bias to a mechanical engineering degree.

Some of the chief objections which may be raised to production engineering as an undergraduate study are :-

1. that undergraduate students are too immature to appreciate the aspects of the subject which deal with human behaviour;
2. that the students' mathematical knowledge is inadequate to deal with either the statistical analysis which is so essential to the operational research approach or the theory of plasticity, without which, much of the study of production processes must be merely semi-empirical;
3. that undergraduate syllabuses are too overcrowded to permit additional subjects and that all of the present subjects are too necessary to be eliminated;
4. that production engineering is not parallel to the other branches of engineering but complementary to them — it is implied in this that production engineering should be studied by men who have already qualified in their chosen branch of engineering.

Counter-arguments, of course, might be put forward, e.g., that immaturity, in terms of years at least, does not prevent young men (and women) from reading for degrees in psychology or sociology; that much of the mathematics taught to undergraduates could be replaced, with much advantage, by a thorough grounding in statistical mathematics; that students should be thoroughly familiar with production processes before any mathematical theories of plasticity are introduced.

The arguments concerning overcrowded syllabuses and production engineering's relationship with the other branches of engineering are less easily countered, due to the fact that there is some element of truth in them — enough to make them controversial points. It is not the purpose of this report to argue the case for or against the extended introduction of production engineering at undergraduate level but, for those who feel agreement with points 3 and 4 mentioned above, the post-graduate course is an interesting alternative.

On such a course the students have already had their basic engineering education and the development of their training in production engineering may proceed untrammelled by extraneous considerations. Furthermore, in the case of production engineering, it is not normal to accept students for a post-graduate course unless they have had a few years' industrial experience and are thus in their middle twenties.

Normally these courses are of a year's duration, and are devoted to lecture-courses and research in approximately equal proportions. The usual qualification awarded upon successful completion of the course is a post-graduate diploma. This is to distinguish it from a higher degree granted for research (M.Sc., or Ph.D.) but it should be noted that Birmingham University grants an M.Sc. for such a course. This is the standard form for a master's degree in American universities, most of the lecture-work corresponding to that given in the final year of an honours course in this country. Birmingham, however, appears to be the only university in the United Kingdom which has departed from the practice normal in Engineering Faculties, of awarding the M.Sc as a research degree. This departure is, in itself, not so serious as the fact that a master's degree is awarded on the strength of only one year's study, i.e., a student at Birmingham is awarded an M.Sc. for a course not materially different from that which would gain an Imperial College student only a College student would have to do two years' research work in order to be eligible for an M.Sc., although for an internal graduate of London University, this may be reduced to one year; in this latter case, however, the whole year would have to be spent on research. It seems undesirable that several universities should grant a post-graduate diploma while one awards what appears to be a superior qualification.

The content of post-graduate courses is more varied than one might think, bearing in mind that a whole year of full-time study is available. Some schemes are predominantly biased towards the management side. Typical of these are the courses in Industrial Management of Glasgow and Cambridge Universities. The former course covers economics, law, psychology, sociology and statistics well but the subject designated Production Engineering is, in fact, a misnomer and would be better entitled Industrial Engineering. The latter course has been mentioned in discussing undergraduate courses and, as pointed out, it is a post-graduate course for some students. Birmingham University offers a course which, on paper, appears to be no less biased towards the non-technological side, since only one subject out of eight is technological, viz., Production Technology. However, this encompasses production processes and metrology which, if dealt with adequately, would mean quite a considerable amount of technological lecture and laboratory work. It is certainly true to say that this course has been one of the most successful post-graduate courses in Production Engineering and has been supported by industry. Dr. N. A. Dudley's recent appointment as Lucas Professor of Engineering Production is welcome to Birmingham, since it means that the Head of the Department once more has professorial status, and to the profession as a whole since it restores the one chair of production engineering which existed in a British university* before Dr. T. U. Matthew's resignation in August, 1955.

**emphasis on technology**

Courses which tend to place the major emphasis on the technological side are those of King's College (University of Durham) and the Manchester College of Science and Technology. The subjects for the King's College diploma are Engineering Production Processes, Engineering Administration, Jig and Tool Design and Statistics. At the Manchester College of Science and Technology candidates for the Diploma in Technical Science are examined in six subjects from the following: Strength of Materials, Mathematics, Statistics, Electrical Measurement, Control Mechanisms, Theory of Metal Processing, Metrology, Production Control and Management Principles.

The Royal College of Science and Technology, Glasgow, and the Imperial College, both offer courses in which technological and non-technological studies are quite well balanced. The Royal College of Science and Technology has a Department of Industrial Administration and the non-technological subjects are studied in this department in the third term; the Imperial College however, has only two faculties — Science and Engineering — and the non-technological work is shared between the Production Engineering Section of the Department of Mechanical Engineering at Imperial College and the London School of Economics. The Production Engineering Section is responsible for the post-graduate course in Production Engineering.

Both Colleges offer basic technological courses in production processes, machine tools, metrology and inspection. The R.C.S.T., also offers technological courses in jig and tool design and metallurgy, while Imperial College's additional courses are concerned with automatic control, economics and plasticity in relation to production processes.

The third term's work at R.C.S.T. corresponds broadly to the Imperial College subjects of Industrial Management, Industrial Engineering and Industrial Sociology but Glasgow appears to have no equivalents for the Imperial College subjects, Statistics and Operations Research. Not all the subjects are compulsory at Imperial College but as the whole course has been discussed recently[3], it is not necessary to elaborate, here, the way in which the choice is made.

The differences in structure between the various post-graduate courses is most desirable, since it enables students to choose the course which satisfies their needs and/or interests best.

The author's impression is that well-qualified candidates for these post-graduate courses are not forthcoming in what could be regarded as adequate

* This interprets a university strictly as defined in the introduction. There is, of course, a Professor of Aircraft Economics and Production at The College of Aeronautics.

numbers, from the point of view of the national need for good production engineers. The two chief aggravating factors are the need in most cases for financial sponsorship and the fact that, when people have reached the age at which they may be accepted for post-graduate studies in production engineering, they are at a point in their industrial career where their companies are most reluctant to lose their services for a complete year. It is to be hoped that in time this situation will improve.

**research**

The most curious feature of the research into technological subjects is the fact that, where it is done by a special production engineering department or section, it is concerned almost solely with the machining process. Instances of this are the University of Birmingham and the three Colleges of Science and Technology at London, Manchester and Glasgow (see Appendix D).

The other production processes are almost invariably covered by universities in which there is no special group for production engineering, e.g., the work on (1) forging, extrusion and indentation at Manchester University; (2) stretch-forming of titanium, deep-drawing and cold-rolling of sheet metal and tube-drawing at high speeds and loads at Sheffield University; (3) wire-drawing and strip-rolling at Leeds University.

There are, of course, exceptions such as the research on the role of work-hardening in metal-cutting at Leeds University and the work of Tobias on milling machine vibrations. It is of interest to note that, at Imperial College, where the Production Engineering Section operates within the Mechanical Engineering Department, the research work on machining is done by the Production Engineering Section whilst that on the other production processes is covered by Professor Ford's Applied Mechanics Group[3].

Of the production engineering departments or groups, as such, only those at Birmingham University and Imperial College cover the field of Industrial Engineering from within their own resources. It is thus not surprising that almost all the research in this field is covered by these two institutions. For convenience, it has been summarised in Appendix E. It should be emphasised, of course, that some of this work is of the type which leans heavily on statistical mathematics and may be *comparable* to work undertaken by Departments of Mathematics which have statisticians interested in operations research. It is not felt to be within the scope of this Report to report on work done by such departments, although it is deemed apposite to mention the point in passing.

The research work follows the usual university pattern, i.e., it is done partly by members of staff and partly by students reading for the higher degrees of M.Sc. and Ph.D.

**conclusion**

The situation of production engineering in British universities has been surveyed as objectively as possible and, while there is certainly room for change and expansion, the position to-day is much better than it was in the immediate post-war years. It is felt by many people that the situation in other countries is very much better. In many cases, comparison is difficult because of the differing ways in which universities have developed in different countries but where comparison is possible, the results are sometimes surprising. For example, of 150 accredited universities in the U.S.A., only 29 offer degrees in either production or industrial engineering and six offer a mechanical degree with production or industrial engineering options. The author feels that most people in Great Britain regard the U.S.A. as a country where production engineering is on a par with other branches, particularly mechanical engineering. The figure of 29 is very low compared with that of 127 for accredited curricula in mechanical engineering and, as a percentage, is not appreciably different from the figure for the U.K.

Apart from a numerical comparison, there is the question of the content of courses. Most engineers in this country know little of the curricula of American universities and to give them some idea of the American approach, the undergraduate and graduate† courses at Ohio State University and the graduate course at the University of Michigan are summarised in Appendix F. Both these universities are among the best in the U.S.A. and it is interesting to note that, as far as the author can ascertain, the University of Michigan is the only A.A.U.‡ or A.A.U. accredited university with a separate Production Engineering Department. Again it would appear that we are on a par with the United States! There are, of course, a number of Departments of Industrial Engineering but for a balanced production engineering education these are not really an entirely satisfactory substitute, as a glance at Appendix F will shew.

The situation on the Continent is more difficult to compare with this country, because of the almost complete separation of the scientific and technological faculties from the Universities. A comparable situation in the U.K. would be one in which no university had a technical faculty and a number of " Imperial Colleges " would be situated in different regions and would all have the effective status of a technical university§.

In most of the countries of Western Europe, there is only one technical institution of university status and either this must cater for production engineering or the country must do without such training at university level. For information, the Western

† American universities use the term *graduate* instead of post-graduate.

‡ Association of American Universities.

§ The more literal translation of the various terms école polytechnique, technische hochschule, tekniska högskolan, etc., is " technical high school ". To avoid a misleading impression, the English translation, " technical university ", is usually employed, but it should be borne in mind that all these languages had words for " university " which were deliberately ignored in creating titles for the technical institutions.

European universities which offer production and industrial engineering are listed in Appendix G. It should be mentioned however, that in these universities, it has been the custom, for many years, to give appreciable training in production engineering to all mechanical engineering students.

In considering the situation in the U.K. and comparing it with the continent and the U.S.A., it is clear that there is an urgent need for more chairs and readerships in production engineering, in order (a) to retain existing staff, who may well leave for a more financially attractive post in industry; (b) to attract men from industry and government departments. Although both these aspects are important, it is obviously critical to retain the few existing staff.

Assuming that staffs can be increased and hence, more post-graduate students accepted, the question of the financing of students arises. D.S.I.R. is obviously unable to bear the whole burden of financing advanced courses of study, and industry can help by sponsoring individual students or by establishing Advanced Study Studentships similar to the few Research Fellowships which already exist. Since the amount of research work which can be done by the universities is dependent on the number of higher degree students and research assistants, it is also essential that some attention be given to this when finance is being considered because, if there is one field of engineering in which this country needs to keep up-to-date, it is production engineering.

We have neither the well-equipped production engineering laboratories of the Technische Hochschule (mainly provided by industrial money) nor the elaborate system of sponsored research which the U.S. Government Departments achieve by placing contracts with universities. Compared with either of these systems, the production engineering resources in British universities are meagre.

A closer liaison with industry as a whole is required in order to keep the university departments in touch with the problems of industry. The work which the universities could do, under good conditions, would justify a Universities Sub-Committee of the Institution's Education Committee. Perhaps some thought could be given to this.


## acknowledgments

It will be evident that this report could not have been completed without the help of many other people. Information was supplied by the relevant members of staff at each university, even including such negative information as confirming that no faculty existed. In view of the large number involved, the author hopes that all those who assisted him wth information will accept a collective, but none the less sincere, expression of gratitude.


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## APPENDIX A

UNIVERSITIES WHICH DO NOT OFFER ANY COURSES OR LECTURES IN PRODUCTION ENGINEERING.

The Queen's University, Belfast. The Universities of Bristol, Edinburgh‡, Exeter*, Hull*, Leicester†, Oxford, Reading*, St. Andrews, Southampton and Wales.

Of those teaching schools of the University of London which offer engineering subjects, King's College does not offer courses in Production Engineering.

## APPENDIX B

DETAILS OF THIRD YEAR PRODUCTION ENGINEERING SUBJECTS AT MANCHESTER AND NEWCASTLE.

**Manchester College of Science and Technology**

Mathematics and Mathematical Statistics
Theory of Machines
Strength of Materials
Hydraulic Control
Designing for Production
Specification and Design of Equipment
Power Station Practice
Electrical Measurement and Control
Metrology
Theory of Metal Processing
Commercial Law, Management Principles, Production Control, Labour Efficiency

**King's College, Newcastle (University of Durham)**

Theory and Design of Machines
Engineering Administration
Engineering Production Processes
Industrial Health
and two of the following subjects:-
Engineering Economics
Fluid Mechanics
History of Engineering
Statistics
Strength of Materials

## APPENDIX C

DETAILS OF THE UNDERGRADUATE COURSE AT LEEDS UNIVERSITY.

**Engineering II (2nd year) — Production Engineering**

*Metrology*: Principles of measurement of length, angles,

‡ This applies to the University itself and not to the Heriot-Watt College.
* No engineering faculty.
† An engineering faculty is, at present, being established.

*APPENDIX C — continued*

straightness, flatness and surface finish. Interferometry. Systems of limits and fits.

*Machine Tools*: The basic machine tools. Tool force and machinability. Tool life equations. Alignment tests. Economic aspects of alternative means of production.

**Engineering III (3rd year) — Engineering Production and Administration**

Plant Layout and Materials Handling
Personnel Administration
Work Study
Factory Costing — Engineering Economic Analysis
Theory of Cutting Tools
Statistical Quality Control

**Engineering IV**

This course is for students reading for Honours. It is a course of advanced study which develops some aspect of the work covered in Engineering III, and in the case of Engineering Production and Administration it develops the theme of Production Planning and Control.

## APPENDIX D

### TECHNOLOGICAL RESEARCH.

**Birmingham University**

1. Determination of the factors involved in grinding efficiency.
2. Effect of technical and human factors on design of machine tool controls.
3. Design and development of a milling dynamometer.
4. The limiting accuracy of surface finish measuring instruments.

**The Royal College of Science and Technology**

1. Methods of surface finish.
2. Mechanics of honing.
3. Fundamental work on metal-cutting.

**The Manchester College of Science and Technology**

1. Machining of carbon steels with carbide tools.
2. Relationship between the physical properties of the work material and the cutting process.
3. Investigation of the parameters which influence the change from one type of chip formation to another.
4. The effect of transient conditions on the steady state in machining.
5. The relationship between machining conditions, surface finish and fatigue strength for a light alloy.
6. Stress conditions in hammer guides under various conditions of impact load.
7. Fundamental research into machine tool design.

**Imperial College of Science and Technology**

1. Stiffness of machine tools.
2. The validity of the plane strain assumption in orthogonal machining.
3. Toughness testing of very brittle materials.
4. Development of boride tool materials.
5. Dimensional analysis in machining.
6. The wear process in cutting tools.
7. The relationship between tool-life and the machining parameters.

## APPENDIX E

### NON-TECHNOLOGICAL RESEARCH.

**Birmingham University**

1. Production losses when one operative attends a number of machines subject to random stoppages.
2 Applications of linear programming to industrial problems.
3. Study of multi-stage production lines and intermediate storage.
4. Significance of output pattern research on incentive schemes and planning of production flowlines.
5. Analysis of motion patterns.
6. Establishment of motion time standards for simple manual tasks.
7. Development of the work sampling technique.
8. An investigation of trends in output rates with regard to operator training and production planning.

**The Imperial College of Science and Technology**

1. Variety reduction.
2. Lot sizes in batch production.
3. The utility of centralised feeder divisions as internal manufacturing divisions.
4. Optimisation of the inspection function in a batch production company.
5. Communication and control in an industrial organisation.
6. Production control and industrial behaviour.
7. Inventory and stock control.
8. Statistical applications in work measurement.

## APPENDIX F

### CURRICULA OF TWO TYPICAL AMERICAN UNIVERSITIES

**Ohio State University**

*Undergraduate subjects*

Motion and time study
Methods analysis
Work measurement
Industrial quality control
Plant equipment and design
Principles of industrial engineering
Work simplification
Production programming

*Graduate course subjects*

Methods engineering
Advanced plant design and materials handling
Operations research
Personnel research
Decision theory
Control theory
Programming and control research
Safety engineering

**University of Michigan**

*Graduate course*

Plant layout and materials handling
Motion and time study
Human engineering
Wages, incentives and job evaluation
Production control
Engineering economy
Operations research
Data processing
Industrial management

## APPENDIX G

### EUROPEAN UNVERSITIES WHICH OFFER PRODUCTION AND INDUSTRIAL ENGINEERING

**Belgium**

Université Libre de Bruxelles.
Université de Gand.
Université de Liège.

**Denmark**

Technical University of Denmark.

**Holland**

Technical University, Delft.

**Norway**

Norwegian Institute of Technology, Trondheim.

**Austria**

Technische Hochschulen of Graz and Vienna.

**Sweden**

Kungliga Tekniska Högskolan, Stockholm.

**Finland**

Technical University, Helsinki.

**Switzerland**

Eidgenössiche Technische Hochschule, Zürich.

**Western Germany**

Technische Hochschulen of Aachen, Darmstadt, Hannover, Munich, and Stuttgart.
Technical University of Berlin.

**France**

Conservatoire Nationale des Arts et Métiers, Paris.

# THE PRODUCTION ENGINEER IN THE BOARD ROOM

by G. RONALD PRYOR, M.I.Prod.E., F.B.I.M.

President,
The Institution of Production Engineers;
Chairman and Managing Director,
Edward Pryor & Son, Limited.

I HAVE given a good deal of thought to the title I have been asked to speak on, and the more I thought about it the less it seemed to me to be a very profitable subject on which to hang a talk, because it implies that the particular qualifications from a professional point of view of a member of a Board of Directors have a greater significance than, in fact, I believe they have. So I am going to be rather naughty and give a twist to the title, as I would much rather approach it from the angle of what I think the young production engineer should have in mind if he aspires eventually to become a member of a Board.

If an analysis is made of the professions of the Managing Directors of a fair sample of successful companies, it will be found that, whether as production engineers we like it or not, the post is just as likely to be held by a mechanical, or an electrical engineer, by an accountant, or by someone who has came up through sales, as by a production engineer.

Let us then look for a moment at the functions of the Board itself. In the August number of The Institution of Production Engineers Journal, Mr. J. L. Gwyther, quoting Sargant Florence, puts this as well as I have ever seen it put: "Lightened by delegation, the 'core' load at the top level of industrial government consists of final decision on policy about:

(a) what and how much to produce;
(b) at what price and what investment; and
(c) of decision on internal organisation, particularly:
  (i) the creation of new posts;
  (ii) appointment to upper posts;
  (iii) top supervision and co-ordination."

It is important to keep this very much in mind. It is true, and indeed it is desirable, that a Board should consist of a well-balanced team drawn from the top executives in the various specialist functions of the business, plus a leavening of outside part-time directors. But if these executives sit round a Board table in their executive capacity, no balanced policy can evolve; Board meetings will be one long struggle between the executives each fighting for his own particular empire. Each must remember that at the Board table he is a member of a policy-formulating group, certainly giving the group the benefit of his own specialist knowledge but, more important, rising out of and above his functions as an executive manager.

What are nowadays accepted in many quarters as the main functions of management ? It may help to crystallise the answer, even if it is an over-simplification, to consider an imaginary situation of a completely new business starting from scratch. Let us assume that a young production engineer has an idea for what he considers to be an improvement of some simple manufactured product — say a thermostat, and decides to start a little business of his own for the manufacture and sale of it. First of all, he will have to acquire some premises and some plant; he will have to arrange for a supply of raw materials or bought-out-finished parts, engage labour, process-plan his

operations, control them, inspect the product and so on. In other words, he is almost entirely concerned with the function of PRODUCTION.

Having had a modicum of success and saturated the small initial market of which he was aware before he started operations, he has now to find additional sales outlets and give his attention to all the sorts of things that are understood by direct sales, sales through merchants, advertising, packaging, exhibitions, foreign agents, possibly market research ; in other words, he is very much occupied with the function of DISTRIBUTION.

Ever since he started, he has had the problem of providing the necessary capital for fixed assets and for working capital, for meeting his suppliers' accounts, for collecting his own accounts and so on. This is the third function of ACCOUNTS AND FINANCE.

He will not last very long against competition unless he is constantly striving still further to improve his product, reduce his operating costs and find new applications for his product. This is the fourth function of DEVELOPMENT; development of design, development of methods, development of markets and, of course, development of organisation.

There is a host of traps and snares waiting for him in the proper observation of the Factory Acts, the Company Act, contracts with suppliers and with customers, insurance and the rest — this is the LEGAL AND SECRETARIAL function.

The sixth function, and I am not putting these in order of importance as this will vary greatly as from one enterprise to the next, is that of PERSONNEL RELATIONSHIPS, a subject which can make a most tremendous difference to the profitability or otherwise of the concern, and to which I will return in greater detail later.

Finally, there is the seventh function of GENERAL MANAGEMENT which co-ordinates the other six :

PRODUCTION
DISTRIBUTION
ACCOUNTS AND FINANCE
DEVELOPMENT
LEGAL AND SECRETARIAL
PERSONNEL RELATIONSHIPS

Now not only are these seven functions, all of them in greater or lesser degree, apparent in every class of undertaking, whether it be manufacturing, the service industries, retailing or professional work, but they are also present in every executive or management position right down the line. The manager of a capstan shop for instance — his production function is obvious; his distribution function is that of planning so that target dates are met for delivery of the product to the assembly shop or the warehouse. He has his own problems of development, of personnel relationships, and he will not be very successful if he thinks he can shelve all these to the drawing office and the labour manager. Obviously he must keep within his own budgets, with an eye always on costs; this is his finance and accounts function, as too there are certain legal obligations of which he must be aware. So that properly approached, even the most junior manager's duties are a microcosm of what takes place round the Board table.

These seven functions can be given the status of "principles". You may give them different names, you may give them different emphasis, but they all need attention all the time, and neglect spells failure. It is when we come to break down each function into the components which make it workable, the methods by which we apply it, that so much difficulty arises and so many of us go wrong.

Let us not forget that the many systems, methods and approaches which have been evolved for implementing these functions are no more than expedients; they are not axiomatic. The trouble is that we are too much like sheep. Someone evolves a system, or a method, which admittedly is startlingly successful in the particular context for which it was devised; papers are written on it, perhaps equipment is sold for it, and before long, what with vested interests of one sort and another, it is given the status of a "principle" and those who do not use it are deemed out-of-date.

But what is right in one company can be very wrong in another, and what is right in one company this year can be very wrong in that same company next year. At all costs we must avoid dogma, because the key word in present-day industry is "change". Even the classical approach to the solving of

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**On 23rd and 24th September, 1959, the Eastern Region of the Institution held their first Conference, at the Assembly House, Norwich. The theme chosen was "Production Engineering as a Function of Management", and the programme comprised the following Papers:**

"The Production Engineer in the Boardroom" by G. Ronald Pryor, President of the Institution.

"Higher Productivity Through Better Administration" by H. H. Norcross.

"Promotion Prospects for the Young Production Engineer" by Harold Burke, Vice-President of the Institution.

"The Power Behind Production" by Canon Noel Boston.

**These four Papers are now reproduced on pages 670-686 of this Journal.**

problems by eliminating all variables but one and then investigating that, is beginning to go by the board. As long ago as the Hawthorne experiment we got a hint of this; that it is dangerous to assume valid results unless the environment is normal, and the very act of formal investigation alters that environment and invalidates the result. In this connection, work of tremendous significance is being done by such people as Dr. Grey Walter, using the technique of electro-encephalography. You will remember that he gave The 1956 Viscount Nuffield Paper to the Institution in January, 1957, and any of you who have not read his book "The Living Brain" will find it of absorbing interest.

Allied techniques are being developed by men like Stafford Beer in connection with Operational Control. So I have no doubt that many of the techniques which we now consider fundamental to our profession, such as current methods of time study, production control, incentives, will, in the not-too-distant future, bear the same relationship to the things that are coming into view as the steam engine now does to the jet engine.

**personnel relationships**

Now, let us look again at some of the seven functions and consider in greater detail some of the facets of them which, in my opinion, merit special and urgent attention. First, personnel relationships. The 20th century has shown a phenomenal acceleration of progress in all the technologies and all the paraphernalia of living. This is not so remarkable, if it is true, as Dr. B. V. Bowden of Manchester College of Science and Technology has said, that of all the scientists and engineers who have ever been in the whole history of mankind, 75% are still alive and working today. But this progress has not been matched in any way by a similar progress in man's treatment of man. Anyone who has paid a visit to one of the concentration camps of the last War (last year I myself, whilst one of the Institution's delegation to Poland, spent a day in the extermination camp at Auschwitz where four million people went through the gas chambers and incinerators) will agree that nothing that we read of as happening in the Dark Ages or in the Spanish Inquisition can compare with the horrors that are still perpetrated by man against man.

But coming back to industry (and here I am paraphrasing the point so well made in our Institution's recent report on "Quality—Its Creation and Control") we should remember that the disappointments that the man on the shop floor suffers, as well as the elations he enjoys, differ in degree only and not fundamentally from those of his employer. He needs to feel that he has a vital contribution to make to his own and his company's prosperity and not that he is a mere number on a clock card, that he is indifferent to everything that occurs at work and only interested in pressing for a shorter and shorter working week. It is quite illogical for us to spend the amount of money we do spend on education; to keep on raising the standard of living and then to deny to the individual in his work, which after all is, or should be, a vital part of his life, the possibility of acquiring that skill which engenders pride and the interest in his job which is engendered by encouragement.

Ted Fletcher, too, had something very succinct to say about this employee satisfaction in a Paper he gave to our South Eastern Region in April last. He said: "The provision of this satisfaction is a basic responsibility of management. The satisfaction may be partly financial, but partly it is social. A man spends the greater part of his waking life at work and society has the duty to see that he gets satisfaction. We cannot support this derelict idea that a man buys his life by going to work for eight hours plus, with one hour for travelling. Somehow the operative must get satisfaction — partly from group relationships and partly from his craft. Can we expect democratic society to be effective and to take conscious, level-headed decisions, unless its citizens obtain a reasonable degree of satisfaction from work? There is nothing really new in this approach to industry. Wolf, one of the disciples of Taylor in the United States, said that no matter how carefully a work study man produces the best method of doing a job, it ceases to be the best method as soon as the operative does not want to do it that way. That is true, but the operative may not want to do it that way for a variety of reasons. As production engineers, we should give consideration to how that aspect of job planning is brought into our responsibilities. Can you leave the question of satisfaction as a casual by-product? You know perfectly well that in the greater part of British industry it has been a by-product for many years."

I know that I am postulating an ideal which it is probably impossible to achieve, but I am sure that we could get so very much nearer to it than we have done if only the same attention were given to it as is given to the technologies of production. Much that is done in the name of incentives, of production control, of quality control, and of welfare itself is nothing but a substitute, and a very poor substitute at that, for good labour relations. Indeed, too often the so-called cure aggravates the disease.

What a ridiculous convention it is that a skilled fitter earning, say, £15 to £20 a week, is on 32 hours' notice and is not paid for time lost through sickness, whilst his 17-year-old daughter, earning, say, a quarter of his salary as a typist, has all staff privileges!

**piece-work**

Again, consider piece-work. I am convinced that in many more cases than at first seem apparent, piece-work is a great evil and mitigates against good labour relations and against quality. Piece-work may be a good thing on large batch production where there is little change of operation and where statistical quality control can be applied. I doubt whether on mass production it has any effect other than as a device for legalising the payment of more than the standard rate, and I am sure that on small batch

production and jobbing work it can be a very bad thing. By its very nature it has a tendency to encourage "scuffle" and shoddy work. It calls for a larger inspection force than would otherwise be necessary. It causes frustrating delays on rejections; it creates a sharp division between operatives and management because there is a natural, if wrong-headed, conflict of interest both on rates and on quality acceptable.

**a personal experience**

I hope you will forgive me if I talk for a minute or two about my own experience. My excuse is that first-hand experience is often more valid than second-hand, and certainly more vital than theory. My own Company is a small one and therefore good labour relations are more easily attainable than they are in companies employing upwards of a thousand people. We are concerned with the manufacture of a very specialised form of engineers' tools and an equally specialised form of machine tool. About 75% of the production is custom-made. Batches rarely exceed six and are often one off. Individual piece-work was introduced more than 40 years ago and, as the Company developed and new departments were started, was extended to these, under pressure from my colleagues but not without considerable misgivings on my part.

Some years ago I became convinced that under these particular conditions piece-work was a bad system. But it is much more difficult to take out piece-work than to put it in, and it took some considerable time to screw our courage to the sticking point of taking such a drastic step. However, it was done two years ago and we have no regrets whatever. Now is not the time to go into any detail as to how it was achieved and what it achieved, but the point I want to make is that it has brought about a quite incredible improvement in labour relations as well as in the versatility and skill of the operatives. Our standards are more easily maintained and production has not suffered. In fact this major change, not alone but coupled with an extensive application of work study (particularly to so-called non-productive departments), has led to a very definite increase in productivity. I know that you can prove anything you like with figures, but these simple statistics are relevant to my point.

In the 12 months ending 30th April last, when we were just beginning to pull out of a very real slump — a slump which has been the subject of considerable understatement in the general press — the real value of our production was ½% up compared with two years ago. By the real value, I mean the sales value corrected for price increase following wage awards. And here is the point — this has been achieved in spite of a reduction of no less than 18% of the total number of people on the payroll. In this particular business, quick delivery is a bigger factor in securing orders than price. The improvement in delivery which has enabled the sales to be kept up has largely been due to the time saved by instituting, in some measure, operator control of quality.

I have always held that the greatest sin which the production engineer can commit is that of dogmatism, and that a close runner-up is the far too prevalent habit of trying to prove the general from the particular. I do not want to fall into that error myself and am not suggesting that all piece-work is wrong, but only that I am convinced that it is wrong in a great many situations where it is now applied. I am fortified in this belief by the fact that, a few years ago, Glasgow University made a field survey in which they found that well over 50% of the industrial disputes covered by the survey stemmed from piece-work rates.

I think the economic philosophy which plays down the importance of the working content of a man's week, is utterly wrong. After the family, a man's work is the most important part of his life; after the family, it is his only excuse for existence in the sense that he is providing a service to the community. In the ultimate Utopia, work should be a joy; you cannot expect to approach this ideal by splitting down operations to such an extent that a man cannot achieve, as I said before, the skill which engenders pride and the interest in his job which is engendered by encouragement. With the increasing pace of progress in technology, this is the sort of thing that should be and can be automated.

**the simple answer**

The answer to the problem is quite simple — implementation of Christianity. I am not competent to develop this thought and must leave it to Canon Boston. But production engineers must be realists in this matter. No factor in the whole industrial field is so potent for success — for high profits, high dividends and rapid development — as good labour relations.

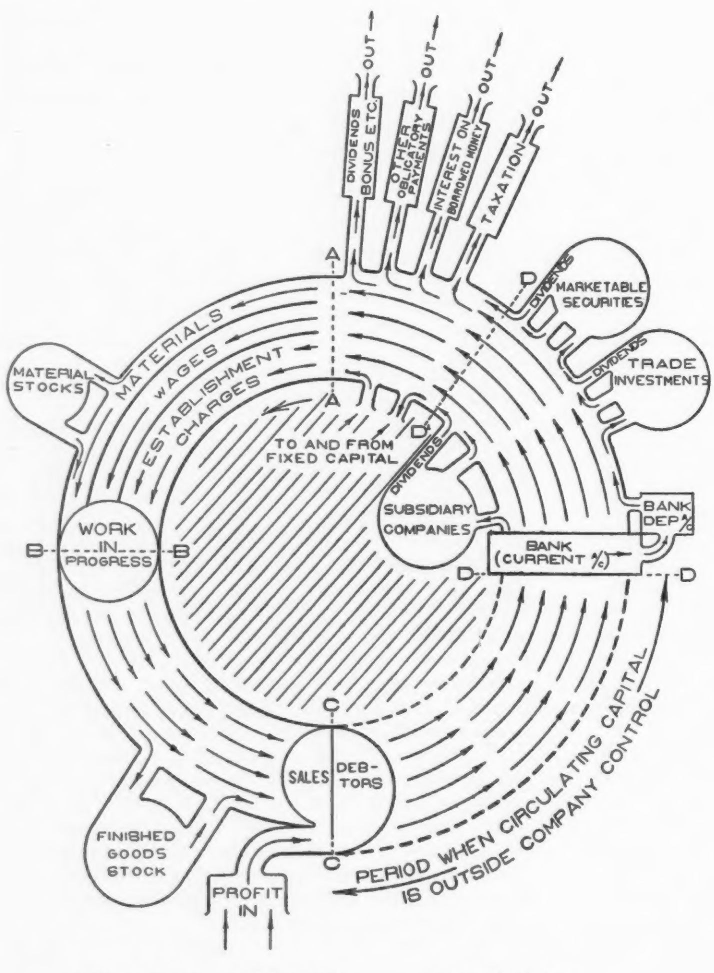
A great statesman said that this is the age of the common man. Lord Hailsham said that this was nonsense, that it is the age of the uncommon man. The 18th century saw a few aristocrats in white silk pants, the 19th century saw many more aristocrats in white collars, and the 20th century looks like seeing a multitude of aristocrats in white coats. This is only another way of stating James Burnham's theme in the Managerial Revolution, in which he set out to show that the aristocracy of any civilisation was vested in those who control the means of production — in other words, nowadays, the technologists and managers.

Industry will have to come round to releasing many more of its young people for sandwich courses in spite of the expense of this. These sorts of things are much more valid and desirable incentives than paying ridiculous rates for mere manual dexterity, and ignoring all the other attributes which are of so much more value to any industrial enterprise. Teachers are the seed corn for future technologists for industry, and industry will have to come round to providing the teachers at whatever inconvenience and refrain from eating its own seed corn.

Next, we come to accounts and finance. It is unfortunate that there is a too common tendency for production people to look upon accountants

as necessary evils. Such a view is wrong-headed; we could not do our job without the services of accountants. They usually do a very good job. But they can only do it within the limits of the sphere of the profession at its present state of development. The error which some of them make is to imply that accountancy is an exact science; it is, of course, nothing of the sort. The income and expenditure accounts for instance, which they produce for us, balance to the last halfpenny. They do so only because a balancing figure is put in to achieve this end; the balancing figure being the profit or loss as the case may be. The actual amount of this balancing figure depends entirely on the figure on the certificate which the Managing Director signs, giving the value of his stocks. Who is to say, with any sort of accuracy, what this value is ? It is a matter of individual custom and what the Inland Revenue will accept as to how much overhead is added to prime cost in valuing stocks. Who is to say with any certainty what proportion of stocks — raw materials, semi-finished parts, or finished parts — will ultimately be saleable or may become obsolete ?

It is interesting to study the diagram shown here, produced by my old friend T. G. Rose, of the relationship between fixed and circulating capital. The temptation to expand trading regardless of maturing liabilities is strong. There is always the feeling that if temporary cash accommodation is needed, it will be found somewhere when the time comes. The result, only too often, is over-trading, increasing financial difficulties and, possibly, in the




CIRCULATING CAPITAL

*Reproduced from "The Internal Finance of Industrial Undertakings" by kind permission of the author, Mr. T. G. Rose, M.I.Prod.E., and the publishers, Sir Isaac Pitman & Sons Ltd.*

end, disaster. To vary the financial conditions of a company is not as easy as to vary the working conditions in a factory, for the reason that financial conditions are all of slow growth, and are not usually susceptible to sudden change. If it is found that the factory is falling steadily behind the sales requirements it is not usually difficult to increase production to make good the deficiency. But if, on the financial side, it is found that the circulating capital is not adequate it is, in the majority of cases, by no means a simple matter to find immediately the additional money required. Once the authorised capital of a company has been issued, and borrowed capital has been added up to the limit of the security that the company can offer, there remains no method by which money can be brought into the business (except by a further issue of share capital) other than by the steady making of profits.

## cost accounts

And then cost accounts. Here I am talking of cost accounts as applied to light engineering batch production and not to the process industries, heavy industry, ship building, etc., of which I have no knowledge. In light engineering, every cost accounting system which I have ever come across applies the overhead either as a rate per hour, or as a percentage of either the prime cost or the direct labour.

It is not unusual for a selling rate to be four, five or even more times the direct labour rate and it is statistically unsound to base a final figure on such a small proportion of itself. In any case, whatever rate is settled can only be correct if the budget figures used for production hours or labour, and overhead expenses, are correct. As we all know, they never are, but we can't go on varying our rates according to the actual figures in every four-weekly accounting period. Just what are the answers to these problems I don't know, but with the increasing use of computers it is probable that more satisfactory techniques will be evolved by the accounting profession in the not-too-distant future.

## development

And now, development. Development is a most important function. I would place it second only, if not equal, to personnel relationships. As I have said before, the key word of modern industry is "change"; progress in the technologies is so rapid that keeping up-to-date with technological progress at any rate is a major problem. The first thing we should do, surely, is to give much greater support to the research associations and not only give them support, but use them. You may think that I have a vested interest here, as Vice-Chairman of the Production Engineering Research Association of Great Britain, but I would not hold that position if I were not so thoroughly convinced that research associations are providing a vital service to British industry, and I am particularly interested in PERA because that research association is so particularly concerned with the implementation and application of research on the shop floor as opposed to pure research itself.

I know from surveys carried out that there are over 10,000 firms in this country who could not help but receive considerable benefit from membership, and yet there are only 800 odd who subscribe. This is a quite incredible state of affairs when the majority of them could be members for less than the wages of a charwoman. It may be that they are already members of their own trade research associations; it may be that they have their own research departments; it may be that they have got wrong ideas from people who subscribe to research associations and then do not use them. It is surely a great folly to miss the benefits which can be bought for so small a cost merely because one is not prepared to take the trouble to make use of the services available, or because one is so wrong-headed as to think one knows it all already.

Perhaps a still more important aspect of development is the development of one's own staff. One of the problems of industry is what to do with the foreman or manager who has been in a company's employ for 20, 25, 30 years; who has given loyal, conscientious and hard-working service to his company, but who has failed to grow with his own job and is now a brake on progress. Those of you who have read "Slide Rule" — the autobiography of the man who, after helping to design the airship R.100, started in a very small way with a capital of £5,000 the Company Airspeed, which Company grew into a large concern, built innumerable aircraft and was eventually taken over by Handley Page; those of you who have read this book will remember that he had this problem in an acute degree. As Managing Director he felt compelled, rightly or wrongly, to remove many of the pioneers who had given him yeoman service in his early days but who had failed to grow with their jobs, until finally he was handed the same cup of tea and himself removed by his Board.

In my opinion, and I have ample evidence that this opinion is correct, an excellent way of stimulating the development of one's staff is to encourage them to seek office as honorary secretaries or members of committees in the various professional associations or learned societies to which they belong, and to give them ample facilities both in clerical help, time and finance, to do the job. There is nothing so stimulating and so conducive to development as regular contact, on intimate terms, with men of greater stature and ability than oneself.

I have nothing to say in detail today about the production, the distribution or the legal and secretarial funcions, not because I consider them less important but because I want to leave plenty of time for discussion, and I will summarise under the seventh function of general management by again reminding you that when you are sitting round a Board table, you should not only be capable of giving expert advice on that particular function of the six

*(concluded on page 680)*

# HIGHER PRODUCTIVITY THROUGH BETTER ADMINISTRATION

by H. H. NORCROSS, F.C.W.A.

Norcross and Partners, Ltd.

GOOD administration can have a powerful effect in raising productivity, but the relationship between administration and productivity is a subtle thing.

In this Paper that relationship is illustrated in two ways: firstly, it is shown by an analogy; and, secondly, by a few case studies.

**an analogy**

Earlier this year there was a car race in which some pre-War E.R.A. racing cars took part. On the same day and on the same racing circuit there was another race for modern sports cars. These two races provided an interesting and valuable opportunity of comparing the performance of the sports car of today with that of the pre-War racing car.

In those car races the lap times for the E.R.A. and the Triumph TR.3 Sports Car were, as near as makes no matter, the same. This is remarkable. It is even more remarkable if the difference in engine power is taken into account, because the brake horsepower of the E.R.A. is about twice that of the Triumph.

One might well wonder why the Triumph can perform as well as a car with twice its power. The answer lies in an understanding of those subtle qualities which lead some cars to "handle" better than others. The Triumph "handles" better than the E.R.A. and this improved "handling" adds enormously to the performance.

Improvements in handling qualities are difficult to explain and to measure, because handling cannot be assessed in simple numerical terms such as are used to measure a factor like brake horsepower. However, the effect of improved handling on the performance of a car is immediately apparent to a skilled driver.

The comparison between the E.R.A. and the Triumph leads to a conclusion which, for many people, is very unexpected. It is on that conclusion that an analogy is drawn between the performance of a car and the performance of a business.

Handling qualities in a car are rather like administration in a business. If you improve handling, you improve performance; if you improve administration in a business, you improve productivity. In each case the relationship between cause and effect is a subtle one, difficult to express in numerical terms.

The analogy can be taken further. Good handling depends on attention to a number of different things — suspension, braking, weight distribution and so on. In the same way, good administration also depends on attention to a number of things — production control, management accounting, stock control, organisation structure, clerical procedures and so on.

**some case studies**

One way to appreciate the relationship between administration and productivity is to study a number of cases where the productivity of a business has been improved as a result of a reorganisation of its administration. A number of case studies of this kind are given as an Appendix to this Paper.

It is important to appreciate, however, that the relationship between improvements in administration and improvements in productivity is not easily expressed in numerical terms. In most of these cases, the reorganisation in the business was concerned not only with administration but also, to some degree, with other matters. It is as if the performance of a motor car had been improved partly by improving the handling qualities and partly by increasing the brake

horsepower of the engine. In this situation, it is difficult to establish a clear arithmetic relationship between the improvements in handling qualities and the improvement in overall performance. It may be a matter of debate, to a greater or lesser degree, as to how much of the improved performance is due to the improved power from the engine and how much is due to improved handling.

Even with this qualification, however, it will be clear from reading these case studies that improved administration has had a very powerful effect indeed on the productivity and prosperity of these particular companies. In each of the companies a reorganisation was undertaken. In each of the companies the reorganisation of its administration was an important factor in the improvement. The aggregate improvement in productivity (measured in terms of increased profit or reductions in cost) for all the companies referred to in the case studies was something in the order of £250,000 a year. Here is powerful evidence indeed to support the statement that improvements in administration bring improvements in productivity.

The term " administration ", as used in this Paper, covers a wide variety of different subjects which can be studied individually. However, it is their effective application together which determines whether or not a company is profitably administered. In this Paper there is some discussion in broad terms of the type of effect, on a company as a whole, of improvements in production control, management accounting, stock control, organisation structure and clerical procedures.

**production control**

One of the purposes of a well-administered production control system is to help co-ordinate production and sales, so that the company is in a favourable position when competing on the score of delivery period. Another purpose of production control is to plan the flow of material and the flow of work in such a way as to make the most efficient use of the labour, material and the other resources of the company. A business should be administered with the intention of getting the optimum overall utilisation of all resources, but sometimes it is not possible to get maximum utilisation of all the individual resources.

In an engineering company, for example, the control of production had been based primarily on the efficient utilisation of the labour. As a result, the labour cost per article was low, but at the same time the overhead cost per article was higher than it should have been, due to low machine utilisation. It was decided to alter this policy and to give greater attention to planning the flow of production, so as to improve the machine utilisation. As a result, profits rose by about £14,000 a year, notwithstanding the fact that a slight increase in labour cost per article had to be faced in order to achieve the higher machine utilisation.

Another business (this time involved in the cutting of leather hides) had based the control of its production primarily on reducing labour costs to the minimum. Here it was decided that more attention ought to be given to efficient utilisation of the leather. A change of policy was made in the production control arrangements, so as to give greater attention to economy in the cutting of leather. As a result, the utilisation of the leather was raised to higher levels. There was a substantial nett increase in profit notwithstanding the fact that, in order to achieve the higher utilisation of material, it had been necessary to allow the labour cost per article to rise slightly.

The point which it is wished to make is that a business should be administered in such a way as to obtain the optimum overall efficiency, rather than basing plans on too narrow an appreciation of the problem.

One important requirement of the production control arrangements is that they should achieve a smooth and steady flow of production, as this can bring a most valuable contribution to the reducing of the overhead cost per article. The first line of attack when considering how to control production is to examine the production processes themselves and the physical layout of the plant. Even in a small business, much can often be done by introducing simple line production. Line production does not necessarily entail the installation of highly expensive mechanical conveyors. In many cases, all that is required is to arrange the machines in a line and have simple wooden chutes between them or perhaps a simple roller conveyor. In this situation it is frequently possible to control the production and to get a smooth and rapid flow, without a great deal of paperwork. In other situations it is necessary to use many more documents, in order to achieve the kind of control which is required. The important thing, however, is not how much paper is used (whether it be a small or a large amount), but how effective is the control.

**management accounting**

The effective use of management accounting can have a tremendous impact on the productivity of a business. One value of this type of control is that it forms a yardstick against which the affairs of the company can be measured from time to time during the course of the year. The amount of detail, and the frequency with which these measurements should be made, will vary from company to company, but it will enable action to be taken where it is shown to be necessary much sooner than would otherwise be possible. What is more, management accounting enables action to be concentrated on the most urgent matters, while leaving items of less importance until later.

Management accounting systems vary widely in complexity. Sometimes relatively simple procedures may be appropriate. In larger and more complicated businesses, advanced forms of control may be desirable, and very considerable specialist knowledge and experience may be needed to design and install the management accounting systems. Whatever the problem, the same basic pattern of thinking has to be applied. There are four stages in a cost control system. Firstly, a sound opinion must be formed of

what the cost should be. Secondly, the actual cost must be measured. Thirdly, the difference between these two has to be investigated and, finally, action must be taken to reduce the excess cost which has been brought to light. It is this fourth and final stage which is the end-product of any cost control system and on which its value rests. The action must often be taken by someone other than the man who provides the figures, so it is of great importance that costing is comprehensible to all levels of management. A business should be administered in such a way that the people in it realise who is responsible for providing cost information, and who is responsible for acting upon it.

This pattern of thinking can be applied not only to the detail matters of cost, but can also be applied to the overall activities of the business. Its application in this way is generally known as budgetary control. Under a budgetary control procedure, forecasts are made of the sales and production of the company over a certain period. By taking these factors into consideration, it is possible to forecast the profit and loss account of the company and the balance sheet position. By means of a budgetary control procedure, it is then possible to show quite clearly and simply at various stages in the period what actual progress has been made as compared with the budget.

The value of such figures is very great when financial plans are being made. It enables an estimate to be prepared of what profits are likely to be available for use in the business, and what demands are likely to be made on the retained profits. If additional finance is needed, it will show how much will be needed and when. It is often cheaper to borrow money if the need for it is known well in advance rather than to be forced to borrow at short notice.

**stock control**

An efficient control over the level of stock held can have a most marked effect on the productivity of a company, whether that company is engaged in retailing, wholesaling or manufacturing. The first requirement of a good control system is to ensure that goods are available when they are required. At the same time, an unreasonable amount of capital should not be tied up in stock. Achievement of these two aims demands, not only a good stock control technique, but also appropriate attention from time to time by management to ensure that changing requirements are adequately catered for.

If stock is not available when it is required by customers, losses of two kinds can occur. Firstly, the company may lose sales to competitors able to offer more prompt delivery. Secondly, if sufficient stock is not available, this adds to the clerical costs. It is easier to deal with an order from a customer immediately it is received, and to send the goods in one delivery, rather than to be obliged to hold the order, keep records in an order book and perhaps despatch the goods in more than one delivery. It is generally much more expensive to "take two bites at the cherry".

The other side of the coin is the cost of holding excessive stock. It is often not appreciated just how great this cost can be. Experience shows that, normally, the additional cost of holding excessive stocks is in the region of 15% to 30% a year on the excessive stock value. In other words, if the value of stock is £200,000 more than it should be, then the extra costs for such things as interest on capital, insurance, additional handling, additional clerical costs and so on amount to something like £30,000 to £60,000 a year.

Good administration is clearly needed if the dangers of insufficient stock and excessive stock are both to be avoided.

**organisation**

The problem of getting a number of people to work together towards a common objective, and to do so willingly and efficiently, is fundamental to good administration. The problem is frequently discussed and sometimes these discussions put too great an emphasis on the mechanics of the problem. The questions of organisation structure, job specifications and so forth are all very well, but more radical thinking is also required.

Organisation is concerned with the relationships between various people in the business. People are not so simple to define and evaluate as, for example, figures on a set of accounts. It is relatively simple to draw an organisation structure chart which conforms to established practice, but it very often happens that the relationships between the people involved are not nearly so tidy and definite as the chart would lead one to believe.

The first requirement of good organisation is to choose the right people to fill the various positions. Staff selection is one of the most vital jobs a manager has to do. Once appropriate people have been selected, the next stage is to ensure that they are properly trained. In this field, in addition to any technical training which may be required, it is important to teach people the art of working smoothly with others. Good leadership from the top is vital to success in any organisation. Where the leadership is right and there is a spirit of confidence and trust in a business, this can do much to compensate for theoretical faults in the organisation structure. The opposite is seldom true.

**the span of control**

The question of what constitutes an appropriate span of control is a problem on which it is wise not to be too dogmatic. To say that five or six subordinates is the correct span of control is an over-simplification and may even confuse the issue. The important thing is to appreciate the effects of an inappropriate span of control.

For example, if a managing director has too few direct subordinates, he may often find himself in a position where they are too busy carrying out his previous instructions to be able to discuss, and take action on, some new matter which has arisen. Under these circumstances, the managing director is tempted to approach someone lower in the chain

of command, to discuss the matter with him and instruct him to take action. A managing director should not bar himself from contacts lower in the company than his immediate subordinates, but he must be aware that, if he does this frequently, he runs the risk of weakening the authority of his subordinates and so making his company less efficient. Another disadvantage of having too narrow a span of control is that the narrower the span, the larger the number of administrative staff required. For example, an organisation structure where the average span of control is six people requires fewer personnel than one where the average span of control is four people.

On the other hand, if a managing director has too many direct subordinates, they often cannot see him about problems which need his opinion and decision. This may cause a physical queue of people outside the managing director's office, or its equivalent on his secretary's pad. A man faced with the problem of not being able to consult his boss has to choose between two undesirable courses of action. He may decide to wait until he can bring up the problem, and delay can be very costly. Alternatively, he may decide to take action without consulting his boss; this also can be costly, as it may lead to an incorrect decision on a problem which really demands an overall knowledge of conditions which the managing director alone possesses.

So, it is often best not to try to solve a problem of organisation by applying to it some theoretical concept of what is the ideal span of control. Rather one should look for symptoms which indicate that the span of control is too wide or too narrow. Different businesses demand different spans of control and men differ in the number of subordinates they can control effectively.

Written job specifications are also often misunderstood. They can be valuable when conditions in a business change and when, for one reason or another, the organisation structure is being altered. They can also be valuable when a new appointment has to be made, as they help to avoid many unnecessary misunderstandings.

### clerical procedures

Good administration depends, to a large degree, on clerical procedures. The level of clerical efficiency in many companies is appallingly low and in this field there is still a very great deal which can be done to increase productivity. However good the executives in a company, they will never be able to give their best work to the business if the clerical procedures on which they depend are slow, inaccurate or unwieldy. Also, if the clerical side of the business is more expensive than it need be, this will eat into profits and reduce productivity.

A sound approach to this problem involves studying the clerical procedures in considerable detail and then challenging each item to see whether it is necessary at all. If it is, one must consider whether it is being done in the best way, in the right place and by the right person. It is astonishing how much clerical work is done which is quite unnecessary. Again, it often happens that a clerical system is changed without the real purpose of the procedure ever having been fully established. The appearance, within recent years, of computers in the office has led to some very fundamental thinking on the real purpose behind the various clerical procedures. Although the introduction of computers for clerical work is at present only desirable in a small proportion of companies, very valuable economies can be made by applying the same basic pattern of thinking to clerical procedures in other businesses, and then reorganising those procedures so as to make use of hand-written methods and various forms of office mechanisation.

### conclusion

To increase productivity it is not sufficient to turn attention to merely one or other of the factors mentioned in this article. Good administration involves attention to them all and to other factors not mentioned here. A constant effort should be made to gain greater smoothness and speed of operation. A business beset by recurrent alarms and frantic decisions is seldom as productive or as profitable as it could be. A manager who thinks ahead and is constantly alert to future developments can do much to avoid being harrassed by sudden crises. A smooth and balanced control of the situation as a whole is often the surest sign that a business is served by good administration.

## APPENDIX

This Appendix includes some brief case studies which have been selected to illustrate, so far as is practicable, some of the effects on a business which can be achieved when the administration is improved. The information has been quoted with the permission of the companies concerned.

### CASE A

*Type of company.* Manufacturer of small tools employing, at the start of the reorganisation, about 200 people.

*The problem.* The company had good products for which there was a large potential market. The following barriers to expansion existed:

(a) the administrative and clerical procedures were too cumbersome;

(b) inadequate costing information was available and the sales price structure needed revision;

(c) production control and cost control were not adequate.

*Action taken and results achieved.* A reorganisation was undertaken. Yearly profits rose as follows:

£36,000
£63,000
£82,000
£143,000

In other words, in four years profits rose by over £100,000 a year.

### CASE B

*Type of company.* A manufacturer of components and sub-assemblies for the motor industry, employing about 800 people.

*The problem.* The company wished to reduce its costs and improve certain aspects of its administrative methods so as to improve its competitive position.

*Action taken and results achieved.* Stock control, production control and cost control methods were reorganised and an incentive plan was introduced for indirect workers. As a result:

(a) an incentive plan reduced indirect labour costs by £10,000 a year;

(b) there was a reduction in the investment in stock and work in progress, after allowing for an increase in the level of activity, of about £200,000;

(c) other substantial benefits accrued but the value of these could not be measured.

### CASE C

*Type of company.* An engineering company in the non-ferrous metal industry employing about 600 people.

*The problem.* To meet severe competition a programme of cost reduction was needed.

*Action taken and results achieved.* The careful application of new methods of cost control and production control showed the way to reduce costs by £43,000 a year.

### CASE D

*Type of company.* A manufacturer of refrigeration cabinets, employing about 150 people.

*The problem.* The company's profits were inadequate.

*Action taken and results achieved.* Programmes were devised and initiated to cover sales forecasting, production programming, production control, financial control, cost control and the design and development of new products. Annual profits were increased by about £19,000 a year.

### CASE E

*Type of company.* Manufacturers of military badges, buttons, and metal small wares, employing about 250 people.

*The problem.* Trading conditions were favourable and the company were making good profits. The directors knew, however, that trading conditions would alter and make business very much more competitive. They were not satisfied that the methods of administration were good enough to meet the more difficult circumstances they saw ahead.

*Action taken and results achieved.* The reorganisation which was undertaken involved, amongst other things, improved methods of management accounting, estimating, office organisation, and sales organisation.

The more difficult trading conditions which the directors had forecast did, in fact, occur. The reorganisation was completed in good time and so far as could be ascertained, the company's profit record was very much better than that of its competitors.

### CASE F

*Type of company.* One of the large steel producing companies.

*The problem.* The company wished to launch a programme for increasing efficiency and reducing costs in the offices of one of its plants. The clerical procedures were complex. Punched cards, keyboard accounting machines and other forms of office mechanisation were already in use.

*Action taken and results achieved.* A reorganisation was undertaken based on the installation of relatively simple and inexpensive electronic equipment. So far there has been a staff economy of 25 people and a net saving in office cost of at least £5,750 a year. The electronic equipment is not fully loaded and further benefits are expected.

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**"THE PRODUCTION ENGINEER IN THE BOARDROOM" —** **concluded from page 675**

with which you are concerned, but also of rising out of and above your executive capacity to make a balanced contribution to the formation of policy as a whole, and when eventually you come to the Managing Director's chair you should remember that it is not too comfortable. That position is a very powerful one, partly because the Managing Director holds the purse-strings and very largely influences what can be spent on development and new plant on the one hand, and on salaries on the other, and partly because he is very largely responsible for appointments and promotions to high level positions. If, as he should, he surrounds himself with men of initiative and vision, he will not have an easy task in welding them into a team and smoothing out conflicts of personality, whereas if he surrounds himself with "yes-men" sooner or later he will make an error of judgment which they will not correct and which will lead to a devastating crash. In either case, his position, in spite of his power, is a very vulnerable one because if he does not satisfy his shareholders they can at any time, in spite of their often being ill-informed and activated by the emotions rather than logic, easily remove him.

# PROMOTION PROSPECTS FOR THE YOUNG PRODUCTION ENGINEER

by HAROLD BURKE, M.I.Mech.E., M.I.Prod.E., F.B.I.M.

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Group Joint Managing Director,
Concentric Manufacturing Company Ltd.

SINCE production engineering as a function of management is the theme of this Conference, it is perhaps not surprising that the address I have prepared is complementary to Mr. Pryor's Paper that we heard yesterday.

Mr. Pryor gave an excellent summary of a Director's duty in the Boardroom, and in the business and, as was to be expected, it provoked considerable discussion. It was interesting to note that a number of members during the discussion felt that very rarely do production engineers get the opportunity of promotion to the Boardroom. A good deal of emphasis was laid on the fact that, in actual practice, directorships — and particularly managing directorships — are so often filled by accountants and sales engineers. There are two things I want to say about that in disagreeing with the comments that were made.

First of all, if you examine the status of the gentlemen present at this Conference, it will be appreciated that the majority of them have done extremely well for themselves and are already holding high positions in industry. Secondly, some years ago, the staff of the Institution carried out some research to ascertain what proportion of senior members of the Institution held directorships, and the results were astonishing. It was found that, not only were a large number of members holding directorships, but that our Institution was outstanding in this regard, compared with other technical professional Institutions. The conclusion reached, therefore, is that production engineers have a very square deal indeed in reaching what is alleged to be "the top of the profession". I would like to say that it does not of necessity follow that, for a production engineer to obtain the most important post in industry in his own field, he must be a director. There are many jobs in this country filled by some of our best production engineers where, due to the size of the organisation in many cases, a directorship was not included in the status of the job.

So, in setting out to decide on what we believe to be the right mentality for the young production engineer, we must have a target constantly before us, and in this regard I would say that the "sky is the limit".

## importance of incentives

Arising from Mr. Pryor's Paper yesterday, there was a good deal of discussion on incentive, and while it is not within my terms of reference to provoke any further discussion on this subject, I would like to make just two points :-

One, that I am a strong believer in incentives, from the shareholders and managing director down to the labourer. It is not terribly important what form this incentive should take, but I believe that it is essential to create the spirit to give everyone the urge to get the best from life, which will enable them to give of their best for the sake of their families, for mankind in general, and for themselves, and, above all, to inspire people to be creative.

My second point on this question is that I have never yet been able to understand how management can control the labour content contained in a manufactured article without some form of incentive system.

In considering the start of a young potential production engineer, one is mindful of the fact that times are rapidly changing but, of course, this has always been so. "Things are not what they were" and the apt reply, "No, they never will be" is a fair description of the changing times. Most of us have seen the family business with inherited responsibility turned into a Public Company, either directly or through mergers with other companies, so that it is no longer an accepted fact that the son of his father should automatically inherit the business. In many ways that is a very good thing.

As regards the basic training which I am sure we all understand is part of the essential life of the young production engineer, he needs guidance in this. He needs to be informed as to what stages in his career he has to make a decision and how he shall divert from the basic training to learn to specialise and become a production engineer. He must have a sense of vocation. The technique of a production engineer is not just a job — it is a way of life. It is both an art and a science. It is the study of the manufacture of articles. It is the business of creation. Therefore, a sense of vocation and a flair for production approaches in this particular regard are essential, and finally he must like doing the job. We expect our student to cultivate a natural instinct and urge to make progress. He has got to learn very early in his career that no one is going to set the pattern for him, but that a wealth of opportunity is presented for him to learn, both as an apprentice and in the technical colleges all over the country that are now giving so much guidance.

### value of practical training

A word on the value of practical training is perhaps appropriate at this stage. How often do we see, in our own experience, the students who think of all sorts of reasons for evading the practical training in the shops? The planning engineers, the designers, the tool draughtsmen and many people of that type seem to regard practical experience as loss of dignity. Time proves how wrong are these ideas and it is, therefore, the duty of more senior men to try and deal with this situation in their day-to-day work. It is their duty as managers to see that as many people as possible under their daily control qualify as early as they can, and they also have a moral responsibility to advise them on how to make the best of their lives. A student has to have the ability to judge the value of training, and assistance in accepting the training pattern. This involves constant study and only those people who have actually experienced this form of concentration over many years realise how difficult it can become. Patience, a thirst for knowledge, and eager acceptance of new thoughts and ideas will lead the student to a much higher standard, and when we examine the organisations with which we are in daily contact, we are conscious of the fact that the trained and qualified production engineer stands out in the organisation.

"How few we have, and how many we want." It is, of course, well known that most companies of any size throughout this country are constantly attempting to find trained men, and therefore opportunities to get better and better jobs must of necessity be always with us. One has only to consider for a moment the impact of automated processes upon the engineering industry to realise the change in training techniques. We want more technical specialists, less operators. Is it a fact that we all recognise? Few of us take the trouble to study what it means in our daily approach to the job.

### problem of responsibility

To proceed a stage further with the qualities that we are looking for in our student, we now come to this problem of responsibility. I regard the sense of responsibility as perhaps the rarest quality of all, because so few people reach out to take it with joy and pleasure. So many people find it difficult to accept responsibility. They have a negative approach to this problem of being responsible for other people's mistakes. It is at this stage that the production engineer has to make a decision, although perhaps he doesn't realise it, as to whether he remains a production engineer or becomes a manager. He is now getting to the point where he has to develop his ability to judge character, to be able to deal successfully with the art of the selection of his subordinates, and to organise his job in such a manner that he can be free to be continuously grasping opportunities of new enterprise and delegating work of a more minor character. This is an essential part of the training of a senior production engineer if he is to reach the heights that he has set for himself. He doesn't realise this at the time. In fact, it is an awareness which comes to him as a gradual process. It is the question of intentness, at all times cultivating the natural instinct for progress. It is, of course, also the ability to judge and grasp the opportunities that present themselves, and it boils down in the long run to appreciation of the "sense of responsibility".

### a high standard

It may be thought that, in analysing the problem so far, the standard has been set very high and indeed it is. But we have to consider whether we have set the standard too high. If we examine what has been done in other countries of the world, for example, in the United States of America, Germany and Russia, it must be recognised that they are making far more rapid progress than we are, in spite of what we have done since the War. We have a much smaller percentage of qualified men in our industry compared with other countries and in broadening our outlook and our field of experience, I cannot stress too highly the necessity for travel whenever the opportunity

occurs. These excursions can rarely be regarded as holidays. They are a matter of intense concentration on new ways of life, new products, new methods, new machines, new people, and generally have to be conducted in an atmosphere of urgency because of the limited time at our disposal. But, nevertheless, each time one visits another factory, whether it is in this country or whether it is in any other part of the world, it is certain that there is something to be learned, even though it cannot be pinpointed immediately and one cannot apply the ideas in the factories at 9 o'clock the next morning. But there is no doubt whatever that the mind broadens and the ideas develop. It is particularly noticeable when you are able to discuss your common problems in another country.

### the Institution's role

Now, in regard to this broadening of one's experience and knowledge, the Institution is playing a terribly important part. Members will have seen the rapid growth of the Institution in its stature since the War, and the more steady growth of its membership. We are not interested in members just to swell the ranks. We are concerned with getting into our Institution, on the one hand, men of mature experience who contribute to the pool of knowledge that needs to be widely disseminated; and, on the other hand, the Student who is anxious to learn how to proceed by stages from Student to a full Member. Technical publications pour out almost every day from so many bodies concerned with technical advancement, and our Institution is no exception to this. The trouble, of course, is that one does not find time to read it all thoroughly, so I commend to you that you study a little the art of rapid reading to help you in this vital matter of extracting from an article the precise piece of information which is of interest to you.

Our Institution has more technical meetings in this country than any other Institution, so far as I know, and certainly we are the specialists on production practices. It is, of course, at these meetings that one not only has the benefit of hearing a Paper from an expert in his subject, but also the chance to meet members and visitors and get to know something of their more personal experiences. It is in this atmosphere that one never fails to learn something of other people's problems and of their solutions; again this broadens the capacity for fresh thinking.

The best way of making a contribution to this is to decide that it is important to work for the Institution, to determine what you can put in, and balance this against what you think you get out of it.

Some years ago, we did some more research on management activities and decided that in a membership of the Institution of just over 9,000 members, more than 1,000 of those members were actively engaged in committees of one kind or another throughout the United Kingdom. That is a much higher percentage than any other technical professional institution that I know, and is very creditable indeed. But there is much more to be done. Many more fields remain to be explored. Members require to be relieved of their responsibilities from time to time and fresh minds are wanted, and this is an opportunity for you. A chance to get closer to the problem, closer to the people, which is bound to have a tremendous effect on your way of life and on your career. And, finally, it is no coincidence that the top men in The Institution of Production Engineers are amongst the top men of industry.

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# THE POWER BEHIND PRODUCTION

by Canon NOEL BOSTON, M.A., F.S.A., R.D.

WHAT on earth is a parson doing talking to a conference of production engineers ? Of course, I may claim to be a production engineer myself, for I suppose that I have to solemnise over 50 marriages a year and if that is not engineering production I don't know what is!

I am here as a parson, as a disciple of One who worked for most of His life in a carpenter's shop at Nazareth, and not as a welfare worker, though the welfare side of things must obviously come into your production.

I intend, then, to endeavour to show that we have very much in common and to suggest that, in production for the sheer joy of production, we have an activity which is not only natural, but essential, if man is to attain his full stature. Of course, I do not use the word production, but *creation*. Now, perhaps, you see why I am here.

The Bible opens : " In the beginning God created the heaven and the earth." A little later, in the very same chapter, it says : "And God said, let us make man in our own image, after our likeness . . . So God created man in His own image, in the image of God created He him."

### a common standpoint

In other words, man is designed to be himself a creator for, unless he becomes a creator, he is failing to be what God has designed him to be. A priest and a production engineer, then, have a great deal in common. The priest is concerned to do all in his power to make men grow more like God, Who is a creator or producer, and a production engineer is concerned in bringing the science of engineering to bear on production. It is not really so strange that I should be with you, and any apparent surprise is itself the measure of our failure to appreciate the true nature of creation and production.

There is a lot in words, and it may be that we must examine those two words very carefully. Is creation synonymous with production ? Can we create without producing, or produce without creating ?

### the creative instinct

It is the instinct to create that is the important thing, and this instinct can be expressed in so many ways. Physically we see it at work in conception and birth, we see it in the products (note that word) of hand, ear and eye ; literature, music, architecture, painting. The psychologist Freud based everything on sex. I do not know how fashionable he is today but if, for 'sex', he had changed the word to 'creative energy' or 'creative impulse', I should certainly not quarrel with his findings. You notice I use the word creation, and not self-expression. There is far too much loose talk about self-expression but, after all, there is no point in self-expression, at least as far as other people are concerned, unless you have a self that is worth expressing. I imagine that in production engineering a most healthy economic law insures that your production is such as appeals to others.

But to return to creation and production. Are both being done ? I can imagine the man at the top, the master mind, the designer, the inventor, finding himself in his invention. There on the drawing board or the rough scribbled note or design is creation. But can it be said to be equally present in the girl who pulls the lever, presses the button or stamps on the pedal hour after hour so that a machine can produce ? Is she creating, is she expressing herself, or is she a slave to the machine so that, to keep her sane, she must be diverted by a

loud-speaker blaring out music whilst she works, until the longed-for hooter puts a period to her slavery and she rushes out to indulge her starved creative instinct in the second-hand delights of television or cinema, or the proxy sport of watching, but not playing in, a football match. The power behind production is the power behind creation itself, and that is the Almighty.

Since man is created in the image of the Creator, man must himself create or fail to be what he was meant to be. We must recognise that this power to create, to produce, is inherent in man's very nature, that it is a divinely inspired immutable law. Unless this is recognised and more than recognised, unless it is fostered and encouraged, those secondary fruits of the production engineer, goods and profit, will never be what they might otherwise be.

The power behind production then is God, and, in human beings this power is a primary power. You are production engineers, not just engineers. In your professional avocations you are, all the time, seeing the thought of the inventor taking concrete physical shape. It is your job to make it so. Here we recognise the existence of a primary state and a secondary state. Both are essential. There is the thought, the idea, which is primary; then there is the materialisation of the thought, the creation of the material object, which is secondary. You, as production engineers, are concerned with both, and in this again you follow divine precedent. Material cannot exist unless mind is behind it. Read through, again, the account of creation in the Book of Genesis. It may well be allegorical but this is outstanding; God, the Universal Mind, existed, and the physical world was called into being. The mind of the designer must visualise his production before ever it can take material form. This relation of Mind and Matter must always be before you, and you must never deny either part. The good designer must be conversant with the practical problems attendant on the materialisation of his designs and, I would like to add, those whose task it is to bring into actual material existence the plans of the designer must not be denied a knowledge of those plans.

### the business motive

So far I have tried to suggest to you that the power behind production is a Divine urge, an inherent and necessary part of the make-up of every human being, just because he or she is human and designed in the image of the Creator. We must now turn to what is, after all, but another aspect of power, namely, motive. Right at the outset we must recognise that this motive may be, and often is, subservient to the expression, the necessary expression, of the urge to create. Now, I believe that the motive of business is profit. A little thought must show that this must be so. Unless we make a profit we cannot achieve the money without which our business, our production, our creation, can be brought about. In this sense the profit motive is absolutely essential, but what I do want to suggest is that this essential profit motive is not an end in itself. It has, I understand, been said that: "If the balance sheet is right, everything is right." This I cannot allow to be true. If it were so, the be-all and end-all of business would be profit. Perhaps this is where the production engineer and the business man, as such, part company. Perhaps it is just here that the production engineer emerges as a professional man in contradistinction to the mere business man, if I may say so without offence. My contention is that, though profit may be an essential part of modern creativity, the satisfaction of the urge to create is, in the end, the final motive.

Has the consideration of this "Power Behind Production" got anything to do with the problems, peculiar among engineers to the production engineer, of the bringing about of production from the labour viewpoint ? Does it, in fact, enter into employer and employee relationships ? Of course it does. The job of the production engineer is, I take it, to produce. To him the drawing board is only of use if the factory can materialise its ideas. In this sense the happiness and quality of the work of the employees must be, not equally important to the production engineer as the condition and maintenance of his machinery, but a lot more so. He must become, in fact, the head of a little community of people and not just of a production unit.

### self-expression in work

That the men and women should be happy in their work is of prime importance and it is also important that they should find themselves in their work. What has been said of the production engineer himself is, all of it, equally true of the men and women he employs. Really the case is one and not two. We seem to have got things so "cock-eyed". It would seem to one outside industry that wages have been exalted till they become more important than anything else. This has had the effect of divorcing cause and result. Instead of actual production, time has, all too often, become the yardstick of the amount to be paid, with the inevitable result that a man thinks he can sell his time.

Let us get this quite straight. A man's time, as such, is of no value whatsoever to anyone except himself and to him it is so valuable that it is beyond price, for it is his life. The time-wage motive, I suggest, is one of the greatest causes of unhappiness and unrest that there is. Unrelated to production, it produces an entirely false economy but, what concerns me more, it produces an entirely wrong attitude to work. A man works through a certain time because in no other way can he qualify for the wage packet. Work thus becomes a necessary evil to be got through. How far modern mass production is responsible for this I do not know, but I believe it is wrong to say that this attitude is brought about by greater and greater mechanisation.

### a possible solution

Automation may be a solution, for it may well restore man to his proper place as a planner, a creator, and abolish the old disgrace of reducing a

human to a mere machine-minder. The trouble seems to be today that we have departed from the old hand creation of things and we have not yet arrived at a creation by machines where man's part is the designing and governing of the machines.

Perhaps we can put it more simply, by saying that what is wanted is that the mass of workers should take a pride in their work and that the employers should see that the tasks to be done are such as allow scope for a pride in work. In other words, give your employees a chance to be creators as well as you yourselves.

You, as production engineers, will know very well the difference in the product of the man who takes a pride, an interest, in his work, and the man who does not. I would go so far as to say that you can see the difference on the faces of the people as you go round a factory. Give everyone you can the chance to have some obvious responsibility, some actual creation, some partnership in the work you are doing. There must be irksome work, I know, especially at the beginning, but could not some scheme be devised in which the boy and girl fresh from school was instructed in the ultimate importance of the little nut or bolt they were making, how its function was necessary, correlating in their own minds their particular task to the output of the factory ? Folding things is not very exciting; yet those girls who folded parachutes in the War were almost infallible. Why ? Because they realised completely the vital nature of what they had to do. Can we get that long view down to the seemingly trivial but essential works ?

## only one problem

Master and man are not two problems, but one. So far we have seen how the scope for creation is essential to both. We saw how profit entered in as an essential but secondary motive. If this is true of master, so it is of man. I am certainly not qualified to enter the complicated paths of industrial economy, but it does seem to be a mad order where a man is paid exactly the same for doing his work well or ill so long as he takes a certain time over it.

In speaking of the Power Behind Production I am dealing with principles, with the immutable laws of creation. They are so often forgotten in the attempt to apply efficiently just what people have forgotten. These principles are my concern. Both they and their applications are yours as production engineers.

I have left till last that aspect of the Power Behind Production which we call service.

First and foremost, the Power Behind Production is the urge to create that lies in every man just because he is made in the image of the Creator. But after each phase of creation, as described in the Book of Genesis, come the words "And God saw that it was good ".

Hence, true creation has in it the element of desiring to do good, to make someone else the better for your creation, your work, and this helping of other people we call service. It is a very important thing and its recognition imparts dignity to any work. It also gives fresh and additional purpose to the quality of our work.

I would like to see posters in factories: " These people are relying on you for . . . . " and then pictures of the various uses to which your particular production may be put. Get that clear and also remember that it is immoral to produce anything which is useless, or of which it can fairly be said that it does no one any good but the person that makes and sells it. The Rotary motto: " Service before self " is a splendid one for the works, but see that it goes right through it. In fact, let the purpose of the production be clear that it is good, let all have their share in its creation and give every encouragement for them to take a pride in their work. Do this and you will find that inherent desire to make, to produce, grows and with it will grow a joy, a new joy found in work.

## improvement

With this new happiness, which is the result of people being given scope for their creative urge, must come a new pride in work and a consequent improvement in quality. These things are of primary importance. They will most surely bring about, also, more sales and more profit, which, though from my angle is of secondary importance, is nonetheless of importance. Moreover, problems of employer-employee relationships will tend to vanish away.

I have tried to suggest to you that a serious consideration of the Power Behind Production is an essential part of your work as production engineers. One of the curses of modern life is that we tend to departmentalise life. Circumstance, training and environment all militate to produce different atmospheres, and when a man from one profession is invited to address another on the ways in which his own concerns impinge on those of the other profession, he is always liable to see the theoretical opportunities, whilst remaining in abysmal ignorance as to the practical difficulties.

## the immutable laws

I have tried to put before you certain basic truths, certain principles, certain theological deductions and what I believe to be immutable laws. I believe that they are essential to the men and women in industry and therefore to industry itself. How to implement these ideas I would not presume to suggest. That is for you to say, for you to work out, but that they can be implemented eventually I firmly believe. No doubt you meet in conference in your various firms over points in policy, production, advertising and the like. As members of a great profession harnessed, by its very nature, to the processes of industry, I would ask you to meet and consider, from time to time, the working out, in your own concerns, of the Power Behind Production.

# QUALITY CONTROL AS APPLIED TO H.R.C. FUSE PRODUCTION

by J. H. Bonaker, A.M.I.E.I.

During May, 1955, the Company began mass producing large quantities of high rupturing capacity fuses, in the course of which all inspection was carried out on a floor-to-floor basis.

It was found from test results that there was a fairly high percentage of rejection. Also, as output was increasing, the management decided that the existing inspection system must be streamlined and improved to enable it to deal with the higher production rate without unnecessarily increasing overheads.

## management policy

The management decided to apply Quality Control methods to the H.R.C. fuse production, and also to set up a Quality Control Department operating within the existing inspection organisation. Immediate training was to be given to senior inspectors who were to be responsible for the operation of the Quality Control scheme, and a general training in quality methods was to be undertaken in due course.

The management also decided that the control schemes used should be simplified as far as possible for general use, and that all technical jargon should be kept away from the shop floor.

The economics of the general production were investigated by the Cost Departments and the Quality Controller was able to inform the Production Department that he was in a position to accept a final rejection figure of 3%. But, obviously all effort must be put into the task of getting below this figure.

## assessment of product variability

Having obtained from the management a maximum acceptance figure of 3%, the next step was to assess the inherent variability of the processes. In other words, was it reasonable to expect that a 3% level could be reached with present methods and layout? With this idea in mind, quality checks were set up at all stages of manufacture using existing methods and materials, and after running these for between three to four weeks it was possible to analyse the results. From this, we found that it was possible to manufacture H.R.C. fuses under existing conditions with a process defective of 3% (approximately). Since the management had already stated that an economical figure was 3%, we now realised that it was possible to forge ahead with the scheme of installing Quality Control on to H.R.C. fuse production, and also to commence to control incoming material and components which were manufactured at Witton (i.e., end tags and caps (Press Section)).

* *"Case Studies in Quality Control" — a course recently organised by The College of Advanced Technology, Birmingham. An introduction and the first four lectures appeared in the November Journal.*

*Mr. Bonaker is Deputy Chief Inspector, Switchworks, at The General Electric Company Limited.*

## training of senior inspectors

A course of five two-hour lectures was arranged for senior inspectors who were responsible for any of the sections where Quality Control was to be applied. These included: Incoming Inspection Department, Press Section, Machine Shop Inspection and Assembly Section.

The object of this course was to introduce these section inspectors to Quality Control methods and to encourage and instil confidence in the system which was to be employed.

It was also pointed out to the senior inspectors that it had been decided that 100% inspection was not achieving the required results and, in any case, from information which had been compiled it was clear that 100% inspection was also uneconomical.

It was also stressed among the senior inspectors that it would be necessary to create confidence in the scheme among production personnel, and this was to be done by applying industrial psychology. We no longer wanted inspectors to play the role of policemen trying to catch out the producers.

Modern Quality Control is the combination of all the devices and techniques that are used to control product quality at the most economical costs which yield adequate customer satisfaction.

A quality product is the result of the co-ordinated efforts of all sections of a production organisation. Adequate, high-grade raw materials must be available, and it must be economically feasible to produce the design specified. The production equipment must be capable of making a quality product and must be properly operated. Inspection must be prepared to detect quality deficiencies at strategic points and to provide data that may be used for corrective action.

> "Quality cannot be inspected into a job; it must be built into it."
>
> "No amount of inspection will improve quality in a direct sense."
>
> "Inspection will only show up bad quality."

## introduction of Quality Control to shop supervision

Before the system was installed, representatives of shop supervision and unions of the departments which would be affected were invited to a meeting to discuss the project, and although there was a certain amount of scepticism *there was no direct opposition*. It was explained that under Quality Control it is fundamental that defects be caught as quickly as possible after being created. This permits prompt corrective action and avoids putting further work into material that will be scrapped anyway. Inspection stations should be close to the operators where important quality characteristics are determined by the processing operations. In some cases this may mean putting control charts on each of a number of operations, and in others a sampling inspection at the end of a processing line.

It is also fundamental that the operator be supplied with the necessary gauges or measuring devices to be sure that she is producing satisfactory work. Making the product right the first time is the goal. Catching defective work after it is made is a poor second-best.

## quality-mindedness

Quality-mindedness is a prerequisite for a quality product. Fortunately, most people want to do good quality work and if given the opportunity will do it, but unfortunately, modern mass production has tended to submerge the natural outlet for pride of workmanship experienced by the craftsman who dealt directly with his customers. The importance of quality was brought home to him forcibly by his customers; poor work brought its penalty quickly. In modern production methods, the workman usually has no direct contact with the consumer.

Furthermore, great pressure is often brought to bear upon him to increase the quantity of his output without a like amount of pressure to increase the quality of his work. Often he is paid by the piece, or given a bonus, for producing more than a "standard" amount under an incentive system that counts all units of work produced, regardless of quality. It is little wonder under such circumstances that product quality is so commonly a major problem

## a "bill of rights"

The workman has a right to certain considerations if we are to expect him to do good work. We might call these considerations "the workman's bill of quality rights". They are:

1. Satisfactory physical conditions under which to work.
2. Good raw materials.
3. The right tools properly maintained.
4. Adequate instructions and training for the job.
5. Good supervision.
6. The means to check his own work.
7. A reward for good quality work.

Deprive the workman of any of the above and quality will suffer. The need for most of them is self-evident, yet all too often they are ignored or neglected. Sometimes it is not possible for the workman to check his own work directly. In such cases, the inspector or whoever does check it should do so as quickly as possible, and immediately inform the worker of the results.

Most important of all, the worker should be rewarded for good quality work. If there is no reward, there is no incentive. One of the most basic human needs is the need for recognition. If we fail to recognise good workmanship, can we blame the workman for not trying? An ounce of praise for good work is worth more than a pound of blame for poor work.

## setting of standards

### *defect classifications*

A fairly common way to classify defects is: critical, major, and minor. A critical defect is one that will make the product completely inoperative. A major defect is one that will materially reduce the efficiency or effectiveness of the product and that will require repair to restore satisfactory service. A minor defect is one that will have little effect upon efficiency or effectiveness and that will not require repair. An additional category sometimes used is incidental defects. These are usually appearance defects that have no bearing upon the functioning of the product, but are indicative of quality of workmanship.

We feel that defect classifications such as the above serve the very useful purpose of directing attention to defects in some reasonable relationship to their seriousness. They are not hard and fast things that can be measured as one measures inches. Their determination requires both technical skill and experience, but even with these limitations they can be helpful in directing control and corrective efforts, and also in helping suppliers understand their customers' needs.

### *incoming materials*

Batches of incoming goods were to be accepted or rejected on the basis of sampling inspection. The sampling plans used by the Company are those issued by Philips Electrical. Inspection records are already kept on classified cards, and the quality history of any item can be seen by glancing at the appropriate card for each of its suppliers. Any action to be taken with a supplier is thus indicated.

Sampling plans were chosen on the basis of an acceptable quality level and a lot tolerance.

The acceptable quality level is chosen according to the nature of the goods, while the lot tolerance depends on previous quality history, batch size, etc.

The extent of raw material inspection may be reduced as confidence in a supplier's quality increases.

The Company is therefore urging its suppliers to use Quality Control technique to improve the quality and consistency of their supplies, and are meeting with some success in this direction. Main troubles arise from supplies of porcelain bodies with $\pm 2\%$ manufacturing tolerance.

### *manufactured components*

These components were the tags and end caps and therefore only three manufacturing departments were involved: the Press Section (producing); Machine Shop (skimming end caps); and the Plating Shop. Fraction Defective Charts were set up in each of these departments to facilitate control.

### *general assembly*

The general assembly of the fuses was broken down for inspection into nine stages and the following forms of Quality Control were applied:

| *Stage* | *Process* | *Control* |
|---|---|---|
| 1. | Manufacture of elements | Statistical control and fractional defective |
| 2. | Stamp bodies | Fractional defectives |
| 3. | Fit inner caps | Fractional defectives |
| 4. | Fit element | Fractional defectives |
| 5. | Solder elements | Fractional defectives |
| 6. | Outer cap, one end, sandfill and plug | Fractional defectives |
| 7. | Outer cap, second end | Fractional defectives |
| 8. | Load and label | Fractional defectives |
| 9. | Final inspection | Batch sampling |

## personnel needed

No hard and fast rules can be set down with respect to the number of people needed to staff a Quality Control group; however, there are some general types or levels of activities that are common to most organisations. These may be concentrated in a few people or spread over many, depending on the size of the company and the nature of the quality problems involved.

First, there is the management activity or direction of the programme. This requires the ability to organise and administer a new programme. Familiarity with the nature of engineering and production problems is highly desirable. Familiarity with the nature of the Quality Control field is a must.

Second, there is the activity of quality planning. This function requires an engineering type of approach. Some of the problems involved are the setting of quality standards; controlling the quality of incoming materials; what to inspect for and where to inspect; what sort of sampling procedures to use; what sort of tests to conduct; how to evaluate the finished product; and how to evaluate the customers' reactions to the product.

Third, there is the activity of gathering data. This function requires the ability to follow detailed instructions, and to observe relevant conditions that may not have been anticipated.

Fourth, there is the activity of recording and handling the data collected. This function may range all the way from the clerical task of recording or tabulating the data collected to the preparation of summaries, graphs or charts, or the analysis of data and its interpretation.

## conclusion

The general scheme which I have outlined is a true record of our efforts at installing Quality Control on to the H.R.C. fuse production, and we are now operating well below our $3\%$ rejection level.

The Inspection Department maintains cordial relations with the H.R.C. Production Department, although it will be accepted that even in the best regulated families some disagreements do arise occasionally. However, the training scheme has provided for this occurrence, and considerable time has been given to instilling into inspection staff the need for patience, tolerance and understanding, and the development of the problem of human relations.

We find that the time was well spent and in general this training has had a beneficial effect upon the section's general quality and output.

# CONTROL OF QUALITY IN THE MANUFACTURE OF BEVEL GEARS

by **G. E. Paterson**

IN this lecture, I propose to give a general practical approach to the controlling of quality in the manufacture of bevel gears.

It will not be possible to cover every aspect of the problem, so those items mentioned should be considered as most essential, for quite a number of points that could be raised are common to the control of quality in most machined parts.

The geometry of a bevel gear is such that its construction is fixed in relationship with a point in space. As it is not possible to measure from this point, it is necessary to fix some other location, in relationship to this point, from which to work.

The gear blank is the body on which the bevel gear teeth are going to be cut, and the accuracy of this blank decides mainly the accuracy of the gear. (Fig. 1.)

As a general rule, in small and medium size gears of good quality for industrial purposes, bores are held to +.0005 in./–.0000 in. and shanks +.0000 in./—.0005 in. These limits may be halved or doubled according to size of gear or quality, i.e., precision.

The axial locating surface, or back face of the hub of the conventional type gear blank, is fully as important as the bore; it is essential that this surface be flat and true with the bore within close limits. The total axial runout should not exceed .0005 in. for good quality gears of small and medium sizes.

The importance of these two surfaces cannot be emphasised too strongly, for the bore locates the blank radially, and the back face locates the blank in its correct relationship with its cone centre or, as we first mentioned, the point in space.

These two surfaces are used for locating the blank for cutting the teeth, testing the pairs together, and generally for final assembly.

On drawings, apart from the general dimensions, angles, etc., the mounting distance and crown to back should be clearly shown. The crown to back is the only physical means of measuring the gear blank, for its correct relationship to its cone centre.

In some instances, it is necessary to remove metal from the back face after teeth have been cut. Where this is so, a datum face should be arranged from which the machining operation can be checked, to ensure correct dimension between the back face and cone centre of the gear or pitch line of the teeth.

## forgings

Forgings play quite a large part in bevel gear manufacture, especially in high production. It is essential to ensure that forgings have been correctly normalised before machining. For carburising steels, it is generally 25°F - 50°F above the carburising temperature.

A straight normalising treatment may provide too soft a metal for machining, and in this case a combination cycle should be used to give a hardness

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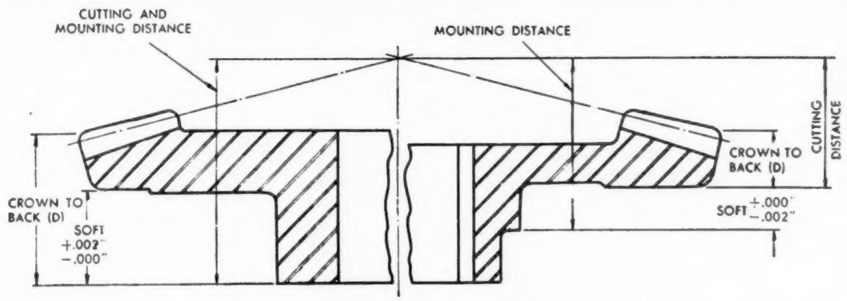
## Gears — Hub Type

Fig. 1.




range of 180 - 200 Brinell. The cycle for annealing is thoroughly soak 1,725° - 1,750°; cool rapidly, air blast 1,200°F; slow cool 50°F per hour to 600°F.

Apart from normalising, incorrect forging prior to the finished forging can affect the grain flow in the blank, so giving distortion after hardening. Fig. 2 shows possible incorrect forging technique applied to pinion forging.

There is generally some change in shape after hardening from the soft cutting, but as long as it is constant, it can be allowed for.

For this reason, when a new cast of metal is used, or a fresh consignment of forgings supplied, trial batches should be cut and processed to note if their reaction after hardening varies from the previous batch. If so, changes can be made in the cutting process for the new supply, based on the trial batch.

The manufacture of the blanks can generally follow that of other similar machine parts, with similar inspection. The main points here are :-

Ensure bore true with back face, then use these surfaces to machine rest of blank.

On shank type pinions ensure working diameters are true with centres, for although pinion is cut off working diameter, it is ground off the centres after hardening.

On small batches or production batches maintain constant dimension between back face and crown apex. Often on small batches this dimension has varied and it has been necessary to alter the machine setting for each blank. (Fig. 1.)

A good blank deserves arbor equipment, and this should be made substantial enough to hold the job rigid, and accurate to hold the job true. Fig. 3 shows a typical arbor.

Blank location surfaces on arbor equipment, when properly installed in the machine spindle, should run true within .0002 in. Fig. 4 illustrates the method of locating the blank in correct cutting position on the machine.

The cutting machines and some testing machines have a vernier attached to the work spindle slide. This vernier enables the front location face of the spindle to be set in relationship to the centre of the machine; for example, if the vernier could be set to zero, the front face of the spindle would be over the centre of the machine.

The taper on the arbor should be made correct so that taper and shoulder contact the work spindle.

The necessity for accurate blanks and emphasis on back face can now be seen. By adding together gear mounting distance " A " and arbor thickness " B ", and setting the work head vernier to the sum of A+B, the blank is correctly positioned in relationship to the machine centre.

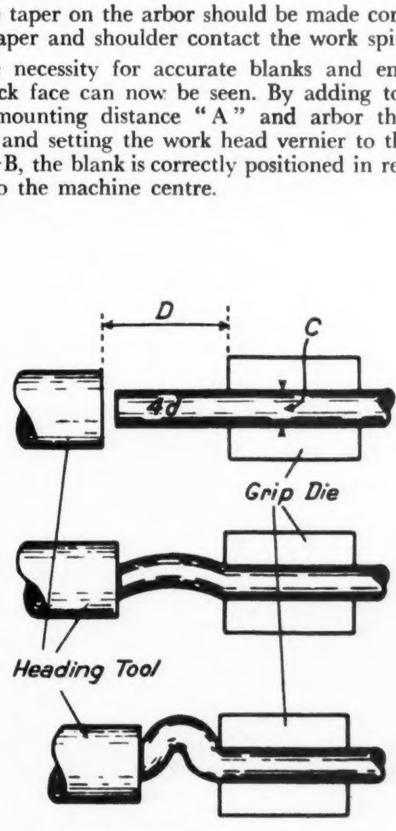



Fig. 2.

Fig. 3. An arbor for roughing gears in the No. 16 hypoid rougher.

Etching the shoulder thickness on arbors ensures correct setting of the machine, and saves time in checking the dimension each time the arbor is used.

### straight bevel gears

Except where special completing cutting methods are used, i.e., the teeth are finished complete in one cut from the solid blank, for good quality gears, the teeth are roughed first to full depth +.005 in./—.010 in. This ensures that the finishing cutters do not cut on the points, but only on the side cutting edges. Sufficient stock should be left on the tooth flanks for finishing, generally about .010 in. per side.

On straight bevel pinions where there is greater profile curvature on the teeth, special cutters can be made to follow closely the finished profile. Otherwise straight bevel gears are roughed with straight-sided cutters.

It is essential when roughing large gears to have a rigid support behind the gear teeth, and also to use a driving pin or keyway to prevent the blank slipping. Using the two tool generator for roughing ensures a taper roughed tooth, whereas roughing the teeth on a milling machine produces a tooth with excess metal on the heel, so giving extra work for the finishing cutters. Straight bevel gears finished by the generating method have the finishing tools attached to cutter slides mounted on a cradle, which rolls in relationship with the work spindle on which the gear to be finished is mounted.

Sufficient roll only is necessary to generate the full profile of the teeth; excess roll affects the finish and cutter life. Roughing as previously described by a milling type cutter makes it necessary to use excess roll for finishing.

Excessive tool strokes in relation to the feed cycle are not necessary. It will be found that often strokes per minute can be reduced as long as flats are not generated on the tooth profile.

Finish should be free from flats, irregular lines along the teeth and tear marks. Soft material is generally the worst for poor finish.

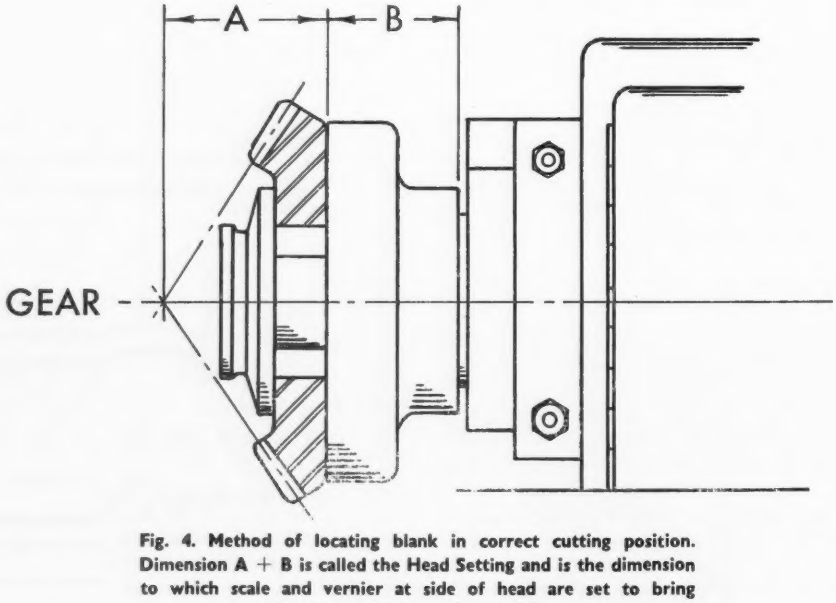



Fig. 4. Method of locating blank in correct cutting position. Dimension A + B is called the Head Setting and is the dimension to which scale and vernier at side of head are set to bring blank in proper cutting position.


**Fig. 5. No. 13 Universal Gear Tester for testing bevel gears operating at any shaft angle. The arrows indicate the adjustments used to change the position of the tooth bearing.**

## testing

Straight bevel gears are tested on testing machines in pairs, either the one produced against its mate being previously cut and used as a master, or against its mate being cut on another machine.

The pairs are rotated by power, one member driving the other member, the driven member having a light brake load exerted on its spindle for bearing location test, and a heavy load if necessary for bearing movement test.

Fig. 5 illustrates a Universal gear tester. The arrows indicate the direction of movements available for fully testing a pair of bevel gears.

Gears being tested are mounted in the test machine at their correct relation to their cone centres, which duplicates the position they will take in final assembly. The setting of the machine centres can be made either by verniers if the machine is fitted with them, in which case the same method as used for the cutting machine is used, i.e., mounting distance plus arbor distance; with setting discs as in Fig. 5A, or with slip gauges.

Checks from the machine can be taken as follows :-

1. *Backlash;* moving the gear members axially into mesh from its correct centre to metal-to-metal contact with the pinion, will give an indication of backlash reading; the amount varies according to pressure angle for .001 in. backlash 14½ PA .002 in. 20°, .0015 in. 25° PA .001 in., or by locking one spindle and checking the gear with a dial indicator at correct centres; locating the indicator directly against gear tooth gives a direct backlash reading.
2. *Concentricity* : by painting the gear teeth with a marking compound, then running them in both directions by power under a light load, the contact points between the teeth will show up as a dark ring against the compound colour.

A true contact ring indicates a true gear.

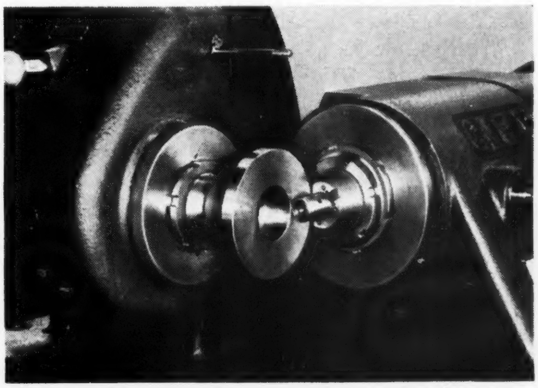


**Fig. 5A. This photograph illustrates the use of set-up gauges for precisely locating testing machine workheads. These gauges are specially made for each job.**

## TOOTH BEARINGS

The following sketches illustrate tooth bearings on the pinion tooth. Although a left-hand pinion is used throughout, the bearings are representative of those on a right-hand pinion or a straight bevel pinion as well.

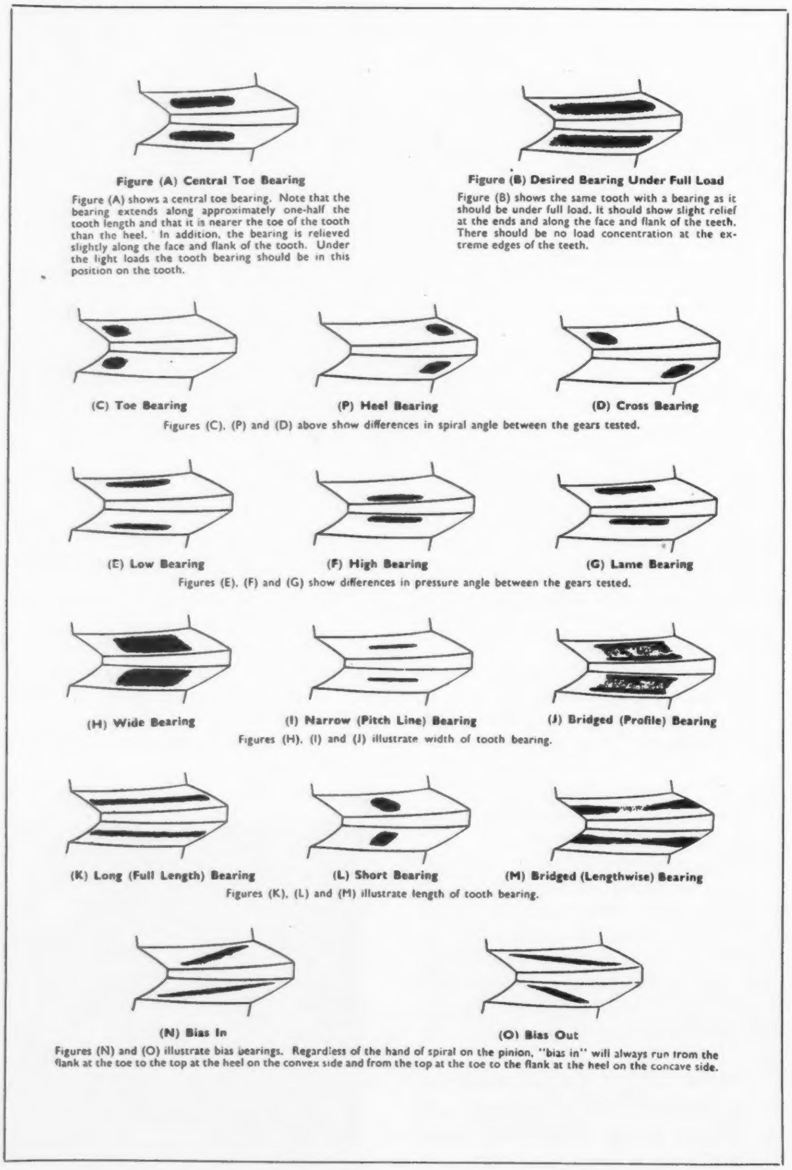


**Figure (A) Central Toe Bearing**

Figure (A) shows a central toe bearing. Note that the bearing extends along approximately one-half the tooth length and that it is nearer the toe of the tooth than the heel. In addition, the bearing is relieved slightly along the face and flank of the tooth. Under the light loads the tooth bearing should be in this position on the tooth.

**Figure (B) Desired Bearing Under Full Load**

Figure (B) shows the same tooth with a bearing as it should be under full load. It should show slight relief at the ends and along the face and flank of the teeth. There should be no load concentration at the extreme edges of the teeth.

**(C) Toe Bearing** **(P) Heel Bearing** **(D) Cross Bearing**

Figures (C), (P) and (D) above show differences in spiral angle between the gears tested.

**(E) Low Bearing** **(F) High Bearing** **(G) Lame Bearing**

Figures (E), (F) and (G) show differences in pressure angle between the gears tested.

**(H) Wide Bearing** **(I) Narrow (Pitch Line) Bearing** **(J) Bridged (Profile) Bearing**

Figures (H), (I) and (J) illustrate width of tooth bearing.

**(K) Long (Full Length) Bearing** **(L) Short Bearing** **(M) Bridged (Lengthwise) Bearing**

Figures (K), (L) and (M) illustrate length of tooth bearing.

**(N) Bias In** **(O) Bias Out**

Figures (N) and (O) illustrate bias bearings. Regardless of the hand of spiral on the pinion, "bias in" will always run from the flank at the toe to the top at the heel on the convex side and from the top at the toe to the flank at the heel on the concave side.

**Fig. 6.**

An eccentric ring indicates runout on which member is out, although in the case of mitres this can be confusing unless the gears are moved in different relationship to each other. On other ratios generally the member with runout shows eccentric contact, and its mate shows a tooth contact the full width of eccentricity.

A break in the ring indicates bad spacing or teeth not cleaned up from roughing.

3. *Running quality* : a smooth quiet running gear indicates correct profile generation; this is also indicated by full profile bearing pattern (Fig. 6). Coarse running generally denotes incorrect setting in cutting machine or test machine; both should be checked unless the test machine has been checked with the master pair; bearing pattern shows either Fig. 6 E or F. The axial position on the test machine of the member being tested can then be altered and trial runs made on the test machine until a correct profile marking is obtained. The amount of alteration required on the test machine for correct running can then be used for an alteration of a cutting machine setting.
4. *Lengthwise bearing position on the tooth* : Fig. 6, A, B, C, D, indicate bearing positions possible. "A" is generally the contact aimed for, and for light loaded gears "B" is asked for. The position for "C" and "A" generally causes some controversy, so the best way is to fix a definite vertical movement above or below centre whichever side is being tested, to give a full length bearing "B". By this check a toe bearing condition can always be duplicated. In the case of "D" pattern, the amount necessary to alter the test machine to produce correct bearing, is also used to alter the cutting tool positions on the cutting machine.

Where straight bevel gears with localised tooth bearing are tested, the lengthwise position can be measured by the amount of vertical position needed to just place bearing at heel or toe and note the amount. Bearing illustrations are for gears with localised bearings, i.e., complex, straight bevels, Zerol, spiral and hypoid gears.

### spiral, hypoid and Zerol gears

The same conditions for spiral, Zerol and hypoid gears apply as for straight, in relation to the accuracy and quality of the blanks, and even more so in the case of automotive rear axle gears, where high quality is required combined with high production.

The tighter control of limits used through the manufacture allows for full use of the final assembly limits, but if some of the limits are used up during manufacture, then fewer limits are available at final assembly.

There are several methods of manufacturing these gears, according to quality, size and quantity required, though the most widely used method for automotive gears is roughing the gear to full depth +.005 in./-.010 in. and finishing at another setup with a cutter cutting each side of a tooth gear.

The gear finishing cutters for high production are in the form of a face mill type broach (Fig. 7). The point width of each pair of blades increases in steps from the first to the last pair, they being spaced apart. The last two blades finish sizing the tooth gap, and indexing takes place between the last finishing blade and the first semi-finish blade.

It will be seen here that close control over the roughing is essential. The first pair of semi-finish blades should hardly cut or not at all, and at the same time the whole of the teeth must clean up.

The point width across the inside and outside blanks determines the thickness of the tooth, having been calculated from the initial gear design.

The pinions are roughed to full depth + .005 in. to .010 in. deeper, then finished in two separate operations with cutters using all outside blades for the concave side of the teeth, and all inside blades

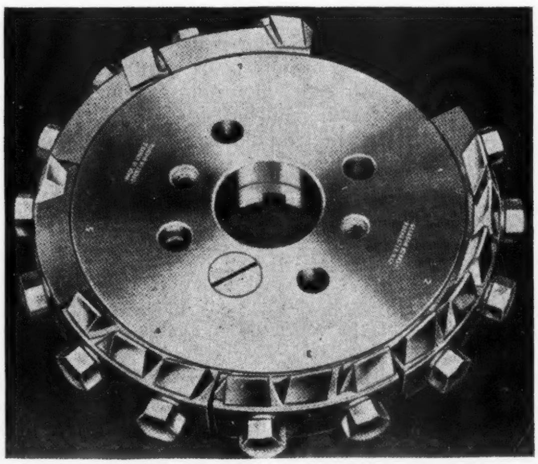


**Fig. 7. Single cycle finishing cutter.**

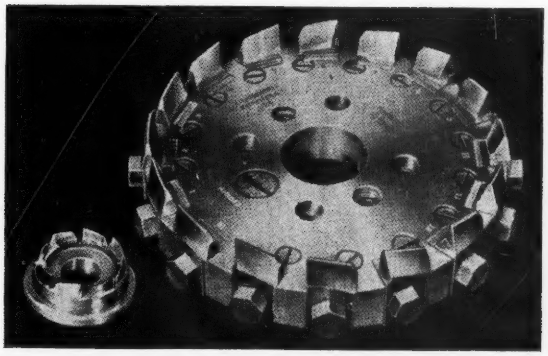


**Fig. 7A. Typical spiral bevel, hypoid and Zerol gear cutters.**

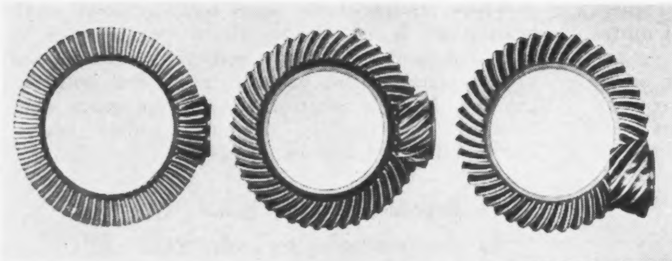


Fig. 8. Zerol, spiral bevel and hypoid gears.

for the convex side of the teeth. Thickness is controlled by stock dividing gauges to give the desired backlash when mated with gear on a testing machine.

Cutters for finishing the pinions (Fig. 7A) are arranged so that each blade can be set radially; the cutters are finally set on the finishing machine and each blade trued spot on using a .0001 in. indicator.

Care in assembling these cutters is essential, for although a cutter may be trued up accurately at one point on the blades, some blades may be off on the angle due to bad assembly. Poor finish due to incorrect truing is shown by flats on the tooth flanks reaching from the root to the tip at an angle; the general finish is round about 100 micro-inches.

Good finish in the sharpening of these cutters is necessary and with care a finish of 12 - 14 micro-inches can be obtained when sharpening. Material conditions being favourable, the finish on gears cut by this method can be from 30 - 75 micro-inches on average automotive gears, and 100 micro-inches for large gears.

Slag inclusions in the metal causes the cutters to chip and results in lines along the teeth; also, soft material clings to the blade edge causing score marks. Extra side rake and experiments with coolants sometimes helps this condition.

A line repeatedly extending from one point of the tooth, even after cutter sharpening, can often be traced to work hardening of the gear blank at that point during the forming operation.

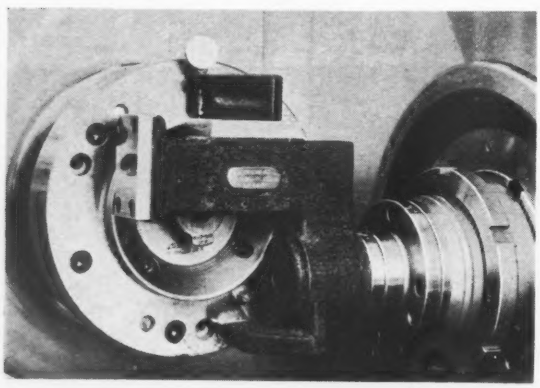


Fig. 9. Hypoid set-up gauge as used on the No. 17 Hypoid Tester.

On special gear finishing machines, it is possible to duplicate the set-up for one particular gear on a number of machines to within a limit of .0002 in. This is accomplished by special gauges.

Gears produced from such a set-up are more or less taken as masters, although for general work the same applies. Providing the gear satisfies to tooth measurements, it is taken as the master to which to develop its mate.

In spiral, hypoid and Zerol pairs, as previously stated (except where some methods complete in one cut), each side of the pinion tooth is completed at a separate operation (Fig. 8). By this means an ideal type of tooth contact is possible for each side, to accommodate different conditions of deflection possible in assembly under load, and also to counteract distortion during heat treatment. Generally there is some form of distortion and as long as the same distortion occurs on each part. it can be allowed for before hardening.

Having determined the type and position of bearing pattern required, the pinion is tested in the testing machine with its master gear.

## use of special gauges

For accurate set-up of the testing machines, special gauges are used. Fig. 9 illustrates a hypoid set-up gauge, which fits into the arbor equipment for the job, and sets pinion and gear mounting distance and also pinion offset.

Fig. 10 illustrates a similar gauge for spiral bevel gears. Here the two spindles are centralised by a tramming ring, while the mounting distances are set by a setting disc similar to that shown in Fig. 5A.

The bearing position and measurement on spiral and hypoid bevel gears are controlled by what is known as the V and H check; the V being a vertical movement up or down of the gear or pinion axis aginst its mate, and the H being the horizontal movement axially of the pinion mounting distance.

An amount of V movement requires an amount of H movement to keep the bearing pattern central on the flank of the tooth. V movement moves the bearing to the heel or toe whichever side is being tested, also slightly to the tip or flank. H movement moves the bearing to the tip or flank of the tooth, also slightly to the heel or toe.

The amount of V to H varies according to the spiral angle and shaft angle, but final trials in assembly determine the correct ratio.

It will be seen that by means of the V and H check the bearing can be positioned anywhere along the tooth length, and a figure obtained for that position which is generally in a relationship with either the heel or toe. As an example, Fig. 6A, which shows a central toe bearing would need, say, V .004 in., H. .004 in. to bring the bearing to the toe (Fig. 6C) and V .015 in. and H .017 in. to bring the bearing to the heel (Fig. 6P). The total vertical movement of V .019 in. and H .021 in. indicates the bearing length.

In positioning the bearing at the heel or toe the bearing should just fade out at those positions and not overlap the edge. The same applies to positioning the profile position. The bearing should just reach the top of the pinion and the root of the pinion at the same time; heavier contact at the root or top of the pinion indicates that the horizontal is out of position.

It is not necessary to make a 100% V and H check, but it should be made after each working break, after any slight change in set up and after each cutter change. There should also be a spot check during production for V and H, also finish and backlash.

Special equipment for checking tooth spacing and gear concentricity is shown in Fig. 11. This is mainly inspection equipment for precise checking of the gears. Similar equipment is used for pinions.

Where further production batches are needed, master gears should be established. These can be extra gears taken from the first batch, providing the quality of the production batch is good enough, otherwise special blanks should be made, but they must be cut under the same conditions as the production batch with regard to tooth particulars.

From there on, future gears are mated with master pinions and future pinions with master gears.

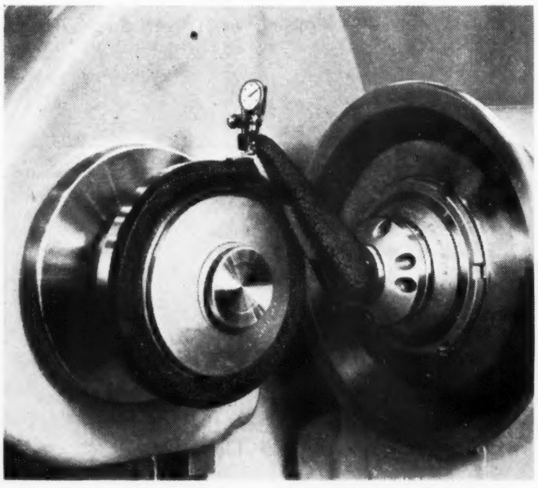


Fig. 10. Tram and ring gauge for positioning the heads of the No. 17 Hypoid Tester.

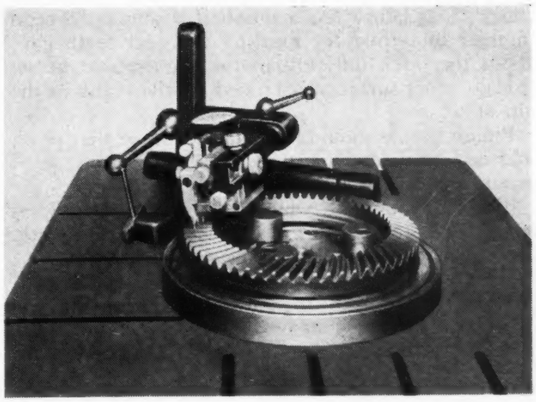


Fig. 11. Equipment for checking tooth spacing and gear concentricity.

Sufficient master pairs should be made to provide :-

1. grand master to check inspection masters;
2. inspection control gears to check finished production gears;
3. green production gears for checking at cutting stage.

Care should be taken in checking with soft masters for wear can soon take place. Greater life can be obtained by using Nitralloy " N " nitrided to a case depth of .005 in. - .010 in., or surface hardening steel with flame-hardened teeth.

## gear hardening

Where gears are hardened, the following points are worth noting, though it is not intended to delve too far into this process.

Whatever the production batch receives in the way of treatment, the other batches must have the same, if similarity is expected between batches. This applies to the following :-

Case depth must be maintained constant for each batch.

It is generally recommended that quenching oil temperature should be maintained constant at a figure of, say, 50°C - 55°C.

Where it is necessary to hold the part in dies while being quenched, particular attention should be paid to the flow of oil over the surfaces of the gear, to prevent uneven cooling of different surfaces.

On modern gear quenching machines, variable pressure on the dies, together with a combination of preset quantities of quenching oil flow at preset times, enables better control of quenching gears to help prevent distortion.

Gears packed back to back in carburising are liable to show uneven distortion, due to uneven patches of carbon on the back faces caused by uneven packing.

Where bores or hubs are ground after hardening, it is preferable to locate the gears on a pitch line

chuck. This chuck has a number of pins set central in their mounting for locating the gear teeth gaps about the pitch line. Otherwise gears should be set true to proof surfaces machined on the blank in the soft state.

Pinion shanks should be straightened, so that proof surfaces run true within .005 in. before hard grinding.

The decision as to whether the gears are left as hardened, lapped in pairs, or ground on the teeth, depends on how they are going to be used.

Where gears are ground, they should still be controlled regarding distortion after hardening, to prevent uneven case removal. Gears to be lapped are generally paired together for removal of any slight burrs put on during the handling of the gears, also for bearing pattern.

Once the gears are lapped in pairs they are kept together and etched with the same number. Mitres should have teeth marked at the positions where they were lapped. The lapping process should be purely a smoothing operation, as excessive lapping can destroy the tooth profile.

Although it is not possible to quote here a case where all the points mentioned were at fault, here is an example which covers some of them.

**quality check following rejections of gears for noisy performance**

The gears in present production were being excessively lapped, showing a ridge at the toe and along the root line of the pinion, the reason being that this was necessary to lap whole length of tooth.

Cutter flats were visible on the pinion flank.

No V and H figures were recorded for soft or hard gears.

Mounting distance for pinion varied from .005 in. to .015 in. over a batch.

Uneven bearing length on gear teeth and pinion teeth indicated bad spacing or some other cause.

Checking pinion at the soft state showed that the bearing had been concentrated so hard at the toe that in effect the true bearing was only half on the tooth. Actually it needed a V and H of 25/25 to position the bearing at the toe. Heavy concentration of the bearing at the root of the flank was also evident, and this would account for ridging at toe and flank after lapping. Cutters were not being trued on the machine.

A V and H figure for a trial batch was recorded, as a basis to work from for further trials to check heat treatment distortion for teeth after hardening.

The first batch of trial pinions was not successful due to variations in mounting distance which varied from .005 in. to .015 in. This was traced to an accumulation of limits allowed for in the machining process. Although pinions were cut at the same setting the cutting location was turned away for carbon removal; also some metal was removed from the face of the pinion, so with the accumulation of limits the original cutting location was lost.

It was arranged for the front location to be untouched, so providing a datum face for the carbon removed to be checked from.

Uneven bearing contact on the gear was traced to index gears having interference, due to incorrect assembly on cutting machine.

Pinions were being wire brushed (machine-driven rotary type) on two occasions, once in the soft state after cutting and again after carburising but before quenching. This wire brushing could, if heavily used, destroy the tooth profile in parts.

The testing machine at first was left fixed on centres with no arrangements for checking the bearing at different points on the teeth. A further testing machine was brought into operation, to check bearing shape and quietness at points along the teeth.

The improvements obtained were :-

1. V and H record for further production;
2. better finish from truing cutters on machine;
3. consistent results from fixed datum face;
4. less time for lapping, no ridges due to over lapping;
5. fewer rejects.

## RELIABILITY AND MAINTENANCE OF DIGITAL COMPUTER SYSTEMS: MANAGERIAL AND ENGINEERING ASPECTS

Discussion meetings on the above have been arranged by The British Computer Society and The Institution of Electrical Engineers, under the aegis of The British Conference on Automation and Computation (of which The Institution of Production Engineers is a member) and will take place at The Institution of Electrical Engineers, Savoy Place, London, W.C.2, on Wednesday and Thursday, **20th** and **21st January, 1960.**

Full particulars of the programme and registration forms may be obtained from the Secretary of The Institution of Electrical Engineers, and must be completed and returned by not later than **1st January, 1960.**

# QUALITY CONTROL IN THE FOOD INDUSTRY

by **J. H. Bushill,** D.Sc., F.R.I.C.

THE present day concept of food quality has so many facets, and there is such a variety of foods, that an attempt to illustrate all the methods of controlling quality would be quite impossible within the compass of one lecture. I propose, therefore, to introduce the subject by indicating very broadly the steps by which Quality Control of food has developed over the years, and then to particularise on methods of such control as applied to a few typical products.

The control of the quality of food may be considered from two aspects, namely :-

1. *Control by legislation* to prevent food adulteration and other undesirable practices, thereby guarding the health of the public.
2. *Control by the food processor* to ensure that his products conform to the requirements of 1, and also to reach and maintain a standard of quality which will satisfactorily compete with those of competitors.

It is appropriate, and not without interest, to review quite briefly the history of the introduction of legislative control in the food industry, before considering the wider aspects of Quality Control with which the food processor is concerned.

## control by legislation

This has in the main three objectives, namely: to prevent adulteration of food; to improve its microbiological condition; and, more recently, to keep within bounds the use of substances incorporated for the purpose of improving the palatability or appearance of food (Food Additives).

For the most part, such legislation was introduced long before science had provided methods of detecting adulteration and before the very existence of micro-organisms was known.

The more important milestones in the development of Quality Control of food by legislation and their relation to a few important dates in the advancement of science are illustrated in Fig. 1, under the following three headings :-

### *(a) adulteration*

As perhaps might be expected, this Table shows that the first item of food which was the subject of legislation was bread (in the reign of King John). The original intention of the Act was to regulate its price, but later clauses regarding adulteration were inserted.

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Legislation concerned with spices, ale, tea and coffee followed at long intervals of time, but for the most part the various enactments were to check false trading and loss of revenue rather than to remove health hazards. These acts were of doubtful value, owing to the lack of means of detecting the adulteration which they forbade.

In the 18th century, it was common practice to incorporate alum in bread and the use of other adulterants such as chalk and bones was suspected. The bakers hotly refuted these charges. Jackson, in 1758, while not denying the use of alum, maintained that the use of other suspected substances was unlikely, as they would not in fact improve the texture or colour of bread. He did, however, expose other types of sophistication of food such as sulphuric acid mixed with vinegar, and the addition of copper salts to improve the colour of green vegetables.

In 1820 (Accum) appeared the first published book on food adulteration, in which the allegations of the type and extent of adulteration were supported by chemical analysis. By then food sophistication had become so widespread that the suggested suppression of the practice met with active opposition. During 1850, the Lancet appointed an "Analytical and Sanitary Commission" to report on the quality of "solids and fluids consumed by all classes of the public". This was instrumental in the first Food and Drugs Act of 1860 being passed. It was subsequently revised and was followed by the 1875 Act, which remained in force for some 60 years.

Food adulteration by the merchants reached its peak during the first half of the 19th century and, following the above-mentioned legislation, slowly declined.

### *(b) micro-organisms*

Until it was suspected that the general condition of food might be affected by living cells too small to be seen by the unaided eye, each person had to assess the quality of his food by its appearance, smell and taste; a bad judgment often resulted in illness and maybe death. When epidemics and plagues became associated in men's minds with the consumption of evil-smelling food (in particular meat and fish) the consumption of such food by one person could result in many being stricken with illness — or so it could be argued. Clearly in such a case the populace needed some form of protection and so developed the practice, in Mediæval and Tudor times, of introducing deterrents to those engaged in the selling of such food. During that period it was the custom for anyone so convicted to be placed in the stocks and for the offending food to be burnt beneath him.

No real advance in knowledge of the causes of food deterioration developed until Pasteur, in 1857, disclosed to an incredulous world his conclusions from his work on fermentation and propounded his "germ" theory in 1878.

That was followed in 1888 by the work of Gaertner who, for the first time, traced the cause of a food poisoning outbreak to a Bacillus, which cause, hitherto, had been suspected but not proved.

The researches of Pasteur and Gaertner pointed to living organisms as a major cause of food deterioration and therefore, to minimise that deterioration, it was natural that any means by which the "growth" of the so-called "germs" could be controlled should be applied. The use of chemical preservatives was initiated.

Although it had been customary to use salt, nitre and vinegar to preserve or pickle foodstuffs since earliest times, the reason for their effects had not hitherto been appreciated. With that knowledge various chemicals including formalin, borate, salicylate, sulphite, etc., came into increasing use.

In 1899 a committee of the Local Government Board was formed to enquire into the use of preservatives (and incidentally also colouring matters) in

**DEVELOPMENT OF CONTROL**

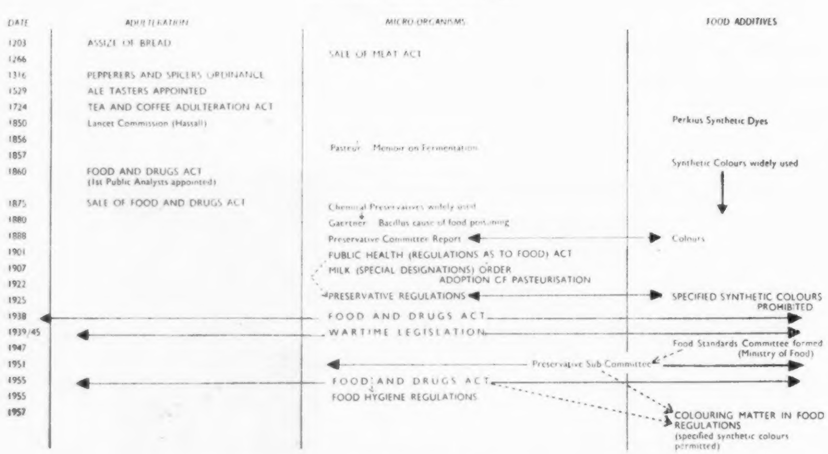


**Fig. 1. Table on Control by Legislation.**

foods. As a result of their enquiries a report was produced in 1901 but legislative action was not taken until 1925, when Preservative Regulations were made.

### (c) food additives

The most recent legislative controls are concerned with what we now term Food Additives.

It has long been the practice of cooks and chefs to make additions of small quantities of colouring, flavouring and other materials to dishes to make them more attractive, but with the growth of chemical knowledge the range of materials so used has considerably increased. Many of these materials have been prepared by chemical synthesis or have been derived from naturally occurring substances. Indeed, in composition many are identical with or closely related to animal or vegetable products. The use of such food additives, which has been one factor in the development of food technology, clearly needs to be kept within safe limits.

Amongst the earliest of these additives were synthetic colouring materials, which came into use very soon after the first organic colouring matter (mauveine) was synthesised by Perkin in 1856.

Although some attention was given to the desirability of controlling the use of colours in foods by the Preservative Committee in its report in 1901, no specified colouring materials were prohibited for such use until 1925. The Ministry of Food Standards Committee formed in 1947 appointed a Sub-Committee in 1951 to study the whole question of Food Additives. Its report on colouring materials formed the basis of a Statutory Instrument now in force. Other reports on antioxidants, and emulsifying and stabilising agents, have already been issued and one on preservatives, etc., is anticipated.

It is interesting to note in Fig. 1 the chronological relationship between food legislation and the growth of scientific knowledge. Legislation to prevent food adulteration was introduced rather before science was equipped to detect such adulteration. Microbiological control of food followed very soon after the existence of micro-organisms was established, but control of food additives, those products of a rapidly advancing technology, followed some considerable time after their use became general. Possibly the lag period may be attributed to the greater responsibility of the present day food processor. And that brings me to a somewhat different type of legislative control, namely :-

## Food Standards

By which is meant the specification of the quantity and type of constituents which *should,* rather than those which *should not,* be present in particular foods.

Unlike food Quality Control by legislation, Food Standards are not primarily intended to protect the public from consuming anything harmful to health but rather to assure the purchaser of a product, of which a standard has been fixed, that the product conforms to a specified minimum composition. Examples of food products which are so specified include cream, fish paste, meat paste, salad cream, mayonnaise, margarine, and ice cream. Food Standards are important in that they ensure that the public gets value for money, but one should bear in mind that when a standard is set it is usually one with which most manufacturers can comply and therefore it is not a particularly high one. As a consequence, the tendency is for manufacturers to keep their products *down* to the standard rather than to improve upon it.

One further note of warning should be sounded, concerning the over-enthusiastic advocates of Food Standards who make a fetish of standardisation by legislation. They are usually not satisfied with standards for a selected few important food products, but must aim at standardisation of food on a grand scale. Such a procedure tends to discourage initiative in the development of food technology.

## rationalisation of international food legislation

In order to complete the picture I have attempted to draw of the development of food Quality Control by legislation, I must mention that it has international complications. Similar or comparable legislation on food quality has, of course, been developed in other countries but the colouring materials, preservatives and other additives allowed in food are not necessarily the same in all countries.

In the absence of authoritative scientific data on the effects on human beings of traces of these substances in diet, these differences in legislative requirement are understandable.

Such differences lead to curious anomalies. For example, from such differences it may be inferred that certain preservatives are harmful to the British but not to the Swiss, and that some additives are harmless in Britain but cannot be tolerated by people residing in Germany.

Rationalisation of food legislation, preferably based on scientific knowledge, is clearly necessary.

Many countries are alive to the importance of this matter and, through the medium of the World Health Organisation (W.H.O.) with the collaboration of the Food and Agriculture Organisation (F.A.O.), are collecting available information and organising research to establish which of the so-called additives (and in what quantities) are not harmful to health when incorporated in food. The incorporation of such information into internationally agreed food standards will need to be accompanied by internationally agreed methods of detecting and determining such food additives. To that end the International Union of Pure and Applied Chemistry (I.U.P.A.C.) is in the process of setting up a special commission.

It is to be hoped that through the joint efforts of W.H.O., F.A.O. and I.U.P.A.C. uniformity in world legislation in regard to Food Additives may be achieved. This incidentally would remove a serious hindrance to international trade in the food industry.

## control by the food processor

Food products may comply with the regulations concerned with sophistication and preservatives, they may be prepared under ideal hygienic conditions and

be perfectly sound bacteriologically, but they may be quite inedible. Furthermore, they may even contain all the nutritive ingredients appropriate to each particular food product but, if they are unpleasing to the eye or to the palate, they will not be eaten. Clearly, therefore, the term "food quality", from the point of view of the public, and therefore of the food processor, embraces far more than can or should be covered by legislation.

Not only must food products have acceptable flavour, texture and appearance, but in addition those qualities must not vary, not only from batch to batch, and from day to day, week to week, but also from the time of manufacture to the time of consumption. To achieve such constancy requires a very high degree of control throughout the complete life history of a product. It commences with the choice of the raw materials and must continue throughout the processing treatment, the packaging, storage, and the transport to the point of sale. It may even take the form of advice to the customer, who may hold the goods for a period before the product is consumed.

The tests applied to the raw materials, apart from showing that the materials satisfy the necessary degree of purity, must be so designed that they provide information as to the properties required in the final product. Furthermore, as food ingredients are mostly of natural origin they are subject to natural variation, and therefore the tests applied must indicate what modifications in the processing are necessary to minimise the effects of those variations.

In considering the processing treatment of food materials, may I remind you that the various techniques are going through a phase of active development towards continuous and automatic processing, with a view to both standardisation and increased rate of production. Different products have reached different stages in this development, which may be considered in three phases. The first is essentially the home cooking method on a somewhat larger scale with mechanical aids, e.g., power whisks and beaters, mechanical mixers, large ovens, but involving much hand labour.

In the second stage, partial mechanisation is introduced with a further increase in rate of production. Machines replace hand operations at many points in the processes and, in the case of a baked article, continuous baking is adopted but the whole operation remains a batch process.

The third stage is represented by a completely mechanised continuous plant with continuous metered flow of ingredients to continuously mixing and processing machines, followed by mechanical portioning and packaging.

In the case of large producers, the third stage has been reached, for example, in ice cream manufacture. The bakery industry is in general at stage two but is actively proceeding towards the attainment of continuous, totally mechanised processes represented by stage three.

With the increase in mechanisation, controlled of course through the agency of instruments recording temperatures, humidities, pressures, rates, etc., there is less opportunity for the art of the chef or the skill of the baker to rectify variations in products during the processing. As a consequence the initial testing and choice of the raw materials, coupled with their standardisation, assumes even greater importance.

In selecting processes to illustrate methods of Quality Control, I have chosen those which have been developed to the stage of large scale continuous operations, as they require the greatest degree of control. Furthermore, with the object of covering as wide a range of techniques as possible, I have chosen the manufacture of ice cream and of a few bakery products. The methods illustrated include the handling of liquids and solids, homogenisation, pasteurisation, freezing, portioning and wrapping.

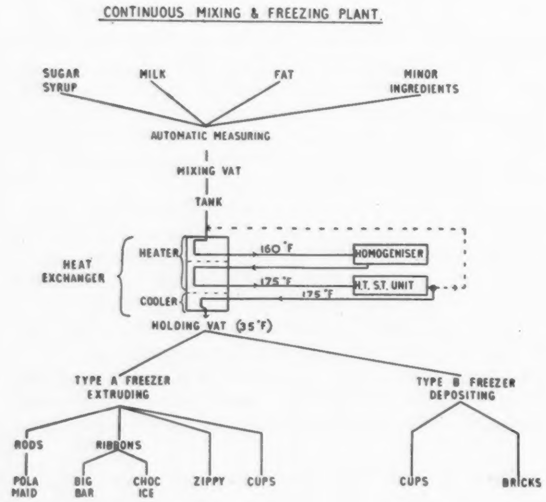


**Fig. 2. Diagram of ice cream process.**

## ice cream manufacture

Apart from the intrinsic quality of the ingredients and their concentration, the quality of ice cream is determined by its bacteriological condition and texture, which are largely dependent upon the design and operational control of the plant used.

After outlining the process as a modern continuous operation I propose to consider in some detail three aspects of quality control: 1. the examination of ingredients; 2. a method of studying formulation; and 3. some indication of the type of problem one meets in designing a continuous refrigeration tunnel to give a product of the required texture.

### *general principles of manufacture*

Ice cream normally consists of a vegetable oil or butter fat dispersed in evaporated, separated milk (or in a solution of dried separated milk) containing sugar, together with a little glyceryl monostearate,

a small percentage of stabiliser and some edible colouring and flavouring materials. The flavouring is mostly of the vanilla type, although a considerable proportion of the ice cream manufactured contains strawberries or strawberry flavour.

The manufacturing process entails the dispersion of the sugar, stabiliser and evaporated milk (or milk powder) in water followed by the fat (containing the glyceryl monostearate), after which the mixture (generally called the "mix") is pasteurised, homogenised and cooled. The ice cream mix then passes to a freezer where air is incorporated at the same time that the mixture is frozen. The somewhat soft ice cream so produced is then either portioned into a variety of containers and then further frozen in a cold store, or it may be formed into large bars and passed through a refrigerated tunnel, where the lower temperature hardens it sufficiently for it to be cut into various portions and then wrapped.

This process which for many years has been essentially of the batch type has now been developed into an almost continuous one, shown diagrammatically in Fig. 2. This continuous process has been made possible by :-

(a) the development of an automatic device for the continuous measuring of the ingredients (all prepared and previously standardised in the liquid form);
(b) the use of high-temperature short-time (H.T.S.T.) pasteurisation, whereby the mix is continuously pasteurised at 175°F for 15 seconds instead of the batch treatment of 160°F for 10 minutes or 150°F for 30 minutes;
(c) the availability of enclosed heat exchangers instead of the original type of surface cooler for cooling the mix;
(d) the extrusion, by continuous freezers, of the ice cream as a ribbon or rod which passes along a refrigerated tunnel from which the fully frozen ice cream emerges and is automatically cut into portions and wrapped.

The extrusion of ice cream as ribbons is illustrated in Fig. 3. Ice cream from a continuous freezer passes along the sanitary pipe at the top of the picture down into each of two conical extruding multiple nozzles, from which emerge horizontally a number of ice cream ribbons which pass into a freezing tunnel. From the far end of the tunnel (not shown) they appear as hardened ice cream ribbons which are automatically cut into portions and then conveyed to a wrapping machine.

Quality Control of ice cream made with such a plant requires, apart from the examination of the purity of ingredients used, standardisation of the sugar syrup, the milk solution, the fat mixture and the solution of the minor ingredients. The efficiency of the automatic measuring device requires checking at intervals by chemical analysis of the continuously prepared mix, which also needs microscopical examination to ensure that the fat globules have been effectively homogenised — otherwise fat would separate by the centrifugal action of the freezers.

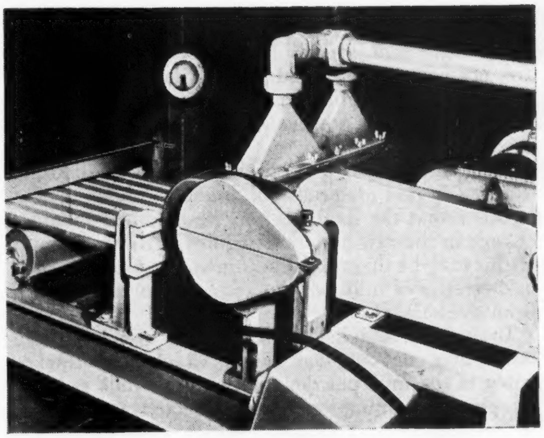

**Fig. 3. Extrusion of ice cream as ribbons.**

Throughout the whole of the process, very careful temperature control is of vital importance to ensure that the heat treatment conforms to the legal requirements. The temperature of the ice cream emerging from the freezers, and of course the degree of aeration (checked by density measurement) both largely determine the consistency of the product.

This consistency must be such that the ice cream ribbon or rod keeps its shape while passing into the freezing tunnel where the ice cream is rapidly hardened; its resulting consistency allows it to be cleanly cut into portions by the automatic cutting device. The cut portions must remain sufficiently hard either to be automatically wrapped, or to be enrobed with chocolate couverture before wrapping.

Every stage in the manufacture has needed extensive study at one time or another to ensure that effective Quality Control is maintained.

### *ingredients*

In examining the ingredients to be used special attention is, of course, paid to those properties most likely to affect the final product. Although the usual chemical means of checking the general quality of the fat are used, the particular property determined is its "induction period". This "induction period" is in effect the time, under specified conditions, that the fat will resist the rapid oxidation which precedes the development of rancid flavours; the greater the "induction period," the less likely is the fat to develop undesirable flavours during storage or when present as an ingredient of ice cream.

The more important of the tests applied to sugar for ice cream manufacture is perhaps the determination of its sucrose rather than its total sugar content. This is because ice cream, being one of the products honoured by having a Food Standard, must contain a specified minimum percentage of sucrose.*

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* Since this lecture was delivered the regulations have been changed; a minimum sucrose content is not now specified.

Evaporated milk (or milk powder) is the remaining major ingredient. Its acidity and total bacterial count are normally determined as an indication of the quality of the original milk from which it was prepared. When milk powder is used, its solubility also is checked.

It is important to keep the various methods of testing the raw materials continuously under review, in order that the methods may be modified should a change in the raw materials require it. As an example of this may be mentioned an unexpected abnormality in deliveries of milk powder received during the War from overseas.

In isolated batches of ice cream mix a curious indefinable flavour was noted which was tracked down to the milk powder solution. The milk powder, on closer examination, was subjected to what is termed a "Breed Count" which determines the total number of bacteria, both dead and alive, in a known volume of a solution of the powder.

In this particular instance the "Breed Count" was found to be abnormally high indicating that the milk, before pasteurising and drying, had a high bacterial count and presumably was in the early stages of souring. The milk powder was not excessively acid, but the alkalinity of its ash was somewhat high, suggesting that alkali had been added. These batches of milk powder were later traced to a supplier who collected milk from farms which had no adequate cooling facilities for the milk and, as a consequence, by the time the milk had been collected at the central factory for condensing and drying, it was commencing to sour. As a consequence of this experience the "Breed Count" was introduced as a routine test of all milk powder received.

### *formulation of the mix: whipping test*

The correct balancing of the ingredients of ice cream mix is dependent not only on their flavour, but also on the ability of the mixture to be aerated sufficiently to produce an ice cream of the desired texture. The physical properties concerned are difficult to measure in absolute terms and therefore one has to devise some empirical means of assessing them.

This has been done by an adaptation of a small batch freezer, consisting essentially of an externally refrigerated cylinder in which paddles are rotated at approximately constant speed by an electric motor, the wattage consumption of which can be recorded. This wattage gives a measure of the resistance offered to the rotation of the paddles and therefore a measure of the change in consistency of a mixture in the freezer.

Liquid mix is placed in the freezer, thereby rather less than half filling it, the paddles are set in motion and the refrigeration turned on. The temperature of the agitated mix falls, thereby causing changes in its composition and physical condition as illustrated in Fig. 4. The ice cream mix is there shown as consisting initially of 37.5% solids (sugar, fat, milk, solids, etc.,) and 62.5% water. On lowering the temperature, conversion of water to ice commences at

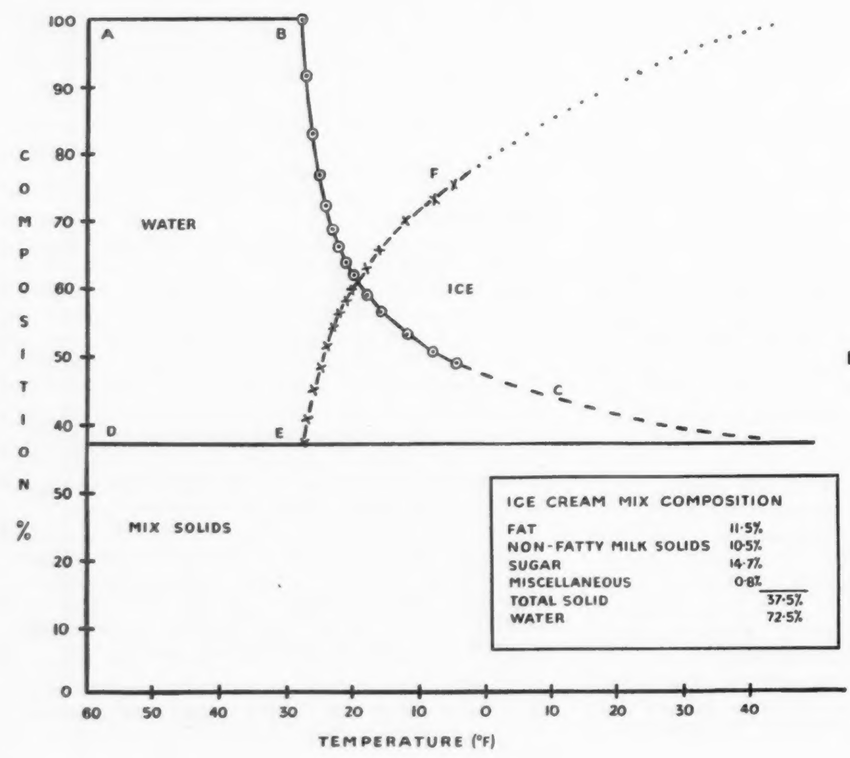



**Fig. 4. Ice cream composition/temperature relationship.**

28°F and proceeds rapidly with further reduction in temperature (Curve A.B.C.). Concurrently the concentration of the milk solids in the remaining water increases (Curve D.E.F.) thereby causing the aqueous phase to become more dense and the mixture still more viscous. While these changes are occurring the beating action of the freezer, aided by the increasing consistency of the mixture, causes air to be incorporated. The percentage aeration is measured at intervals by removing small samples for density determination and the change in "consistency" (wattage consumption) is continuously recorded.

The aeration (measured as percentage overrun in the ice cream trade) and the "consistency" are not directly related; indeed, while the latter continues to increase as freezing progresses, the former may do so only until a maximum is reached, and should the beating and freezing be further continued considerable loss of incorporated air may result. In our investigations we judge the whipping or aerating property of a mix by the percentage overrun obtained at certain "consistencies" determined in the manner indicated.

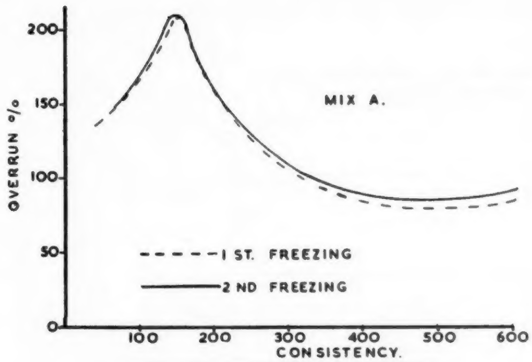
In practice it has been found more convenient in carrying out the whipping test to reverse the previously described process, namely, first to whip and freeze the mix and then to switch off the refrigeration and to follow the change in aeration and in "consistency" as the temperature of the mixture slowly rises. This gives similar results but as the change in temperature is more gradual, the test can be carried out more accurately.

Another variation in the test is obtained by repeating the process of freezing and thawing two or three times, using the same sample of mix. By so doing one can learn something of the stability of the mix, a property which is reflected in the stability of the resulting ice cream under conditions of fluctuating temperature during transport and during storage.

Typical examples of whipping tests demonstrating the difference between a mix of good stability (Mix A) and one of poor stability (Mix B) are shown in Fig. 5.

The above-mentioned whipping test is perhaps more directly applicable to freezing by a batch freezer than by a continuous freezer, by virtue of the difference in the action of the two freezers. In the latter the mix and air, in predetermined proportions, is passed through a narrow refrigerated cylinder, where, by mechanical action, the air is dispersed as fine bubbles in the mix. With such a freezer percentage overrun is largely independent of the whipping property of the mix. The whipping property of the mix is still important, however, as the aerating property of the mix is believed to be a factor both in retaining the air in the frozen ice cream and in determining its texture.

WHIPPING TEST.




| MIX | FREEZING | OVERRUN % CONSISTENCY 200 | 300 | 400 |
|---|---|---|---|---|
| A | 1 ST. RUN | 155 | 104 | 83 |
| | 2 ND. " | 155 | 107 | 88 |
| B | 1 ST RUN | 137 | 91 | 73 |
| | 2 ND " | 95 | 64 | 55 |

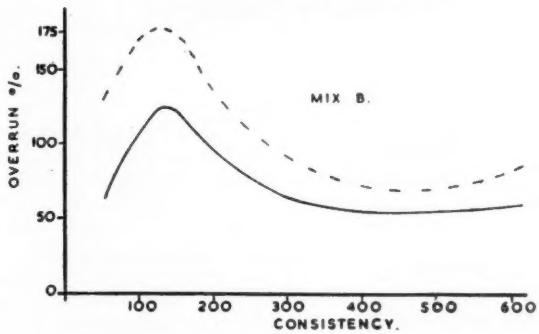



**Fig. 5. Whipping test—mixes of different whipping property.**

### *texture of ice cream as a factor in quality*

Although the ingredients and the proportion of air incorporated contribute to the texture of ice cream, another very important factor is the size of the ice crystals present; the smaller the ice crystals, the finer the texture. Small ice crystals are formed by rapid freezing and it is for that reason that the present-day continuous freezers yield smoother ice cream. The whole of the freezing, however, does not take place in the freezer; further freezing is effected in a cold store or in a freezing tunnel, the latter having the advantage over the former of increased rate of freezing and, as has been indicated earlier, of being adaptable to continuous operation.

The development and control of a freezing tunnel, which will produce a continuous ribbon or separate rods of ice cream, frozen to the stage that the ice cream can be cleanly cut at the moment it reaches the automatic cutter, and will still be sufficiently firm to be conveyed to and be wrapped by an automatic wrapping unit, requires very careful study. If the temperature of the ice cream on leaving the tunnel

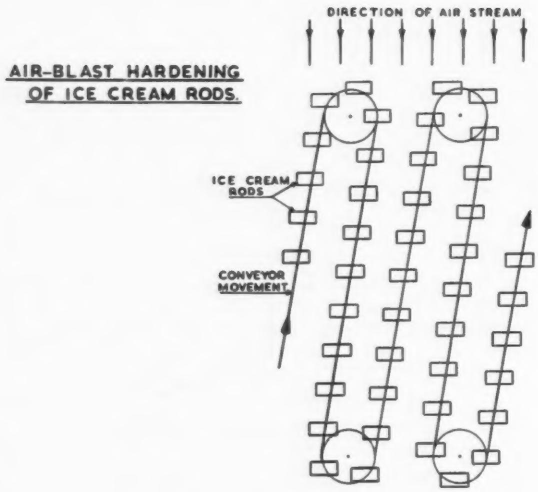



Fig. 6. Air blast hardening of ice cream rods.

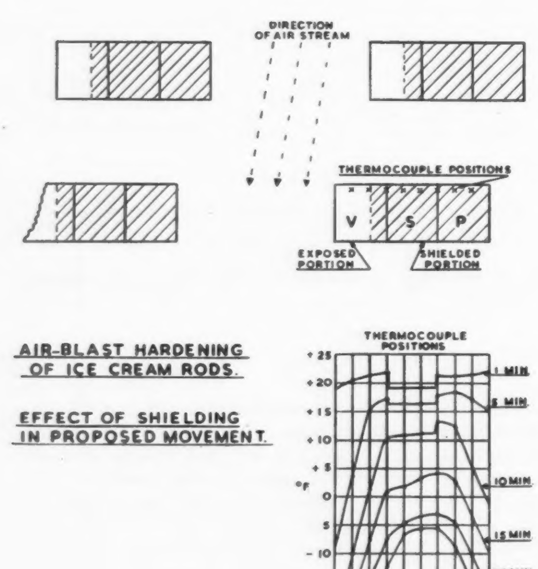



Fig. 7. Air blast hardening effect of shielding from blast.

is too low, there is a danger of the cutting knives being broken and if it is too high, the ice cream will be too soft to wrap.

This effect of temperature on ice cream is clearly illustrated by Fig. 4 which shows that on leaving the freezer at, say, 21°F, approximately 60% of the water has been converted to ice. Further lowering of the temperature markedly increases the proportion of ice until at –20°F, when the ice cream is brick hard, virtually all the water is present as ice. By controlling the temperature one can, therefore, control consistency of ice cream.

For the ice cream to be cleanly cut its consistency must be uniform; there must not be an outer shell of hard ice cream with a soft centre. Such uniform consistency can only be obtained by ensuring uniform temperature in the ice cream. This is not a simple matter with a product of low heat conductivity in a freezing tunnel with a high rate of heat removal.

An early experiment undertaken to provide data on which to base the design of a freezing tunnel will illustrate the type of problem set by the above requirements.

Long rods of ice cream of rectangular cross-section, extruded from the freezer at + 21°F, were to be rapidly hardened in a low temperature air blast and were to be of uniform temperature throughout. The direction and rate of improvement of the rods in the tunnel needed to be studied. One proposed movement of the rods through the hardening tunnel is shown in Fig. 6, in which the rods are shown in cross-section. As the bulk of the air would pass down the channels between the ice cream rods, the left hand part of each rod would be fully exposed and the right hand part shielded by the rod in front of it. In one of the tests made on this method of conveyance, the changing temperatures in a rod were determined with the aid of recording equipment, and specially designed thermo-couples placed in the rod at points near to and equidistant from the face of the rod moving against the air stream. Fig. 7 shows the location of the thermo-couples and the developing temperature gradient from side to side of the rod. In this particular test triple-flavoured ice cream was used, consisting of vanilla, strawberry and pistachio, indicated as V, S and P respectively. As the sugar content of strawberry ice cream—the middle strip—differs from that of vanilla and pistachio, its temperature at the extrusion stage is made lower by 2°F to obtain uniform consistency for perfect extrusion. The dissymmetry of the temperature gradient that developed in the rods during hardening, shown after periods of time 1 - 25 minutes, was due entirely to the shielding from the air blast already mentioned. The shaded portion shows the part shielded from the air blast. After 25 minutes the left side is colder than the right by 12°F and colder than the mid-point by no less than 29°F. The relatively huge temperature gradient of 29°F between the centre and outside of the ice cream rod, a distance rather less than 1 in., is attributable to the high rate of cooling of a poor thermally conducting material. This temperature difference demonstrated the need for a time period,

after leaving the air blast, to allow heat transfer to occur within the ice cream rods. By that means the ice cream acquired a uniform temperature, thereby allowing cutting by the automatic cutter to be performed in an efficient manner.

The above data is typical of the information which needs to be obtained if tunnels are to be constructed to produce exactly the product required.

## bakery products

### *sponge cake manufacture*

An example of a bakery process which has been developed to the stage of a continuous operation is the manufacture of sponge cakes.

The general principle of the process, indicated diagrammatically in Fig. 8, consists of the mixing of the required proportions of flour, egg and sugar in a closed vessel under an air pressure of 15 lb. p.s.i., a subsequent addition of a further small proportion of flour mixed with the required amount of baking powder, and then the ejection of the mixture into a depositor.

The advantage of aeration under pressure is one of speed, for on releasing the pressure the air bubbles already dispersed in the mixture expand, thereby producing a degree of aeration equivalent to that normally achieved after a much longer period of mixing.

From the " depositor " the mixture is automatically measured into depressions in metal trays passing beneath on a continuous chain mechanism. The trays are previously coated with a film of suitable greasing mixture by means of a spraying device.

The sponge mixture in the trays is then lightly dusted with sugar and passes through a continuous oven at a controlled temperature and, of course, is baked for a definite time period. The baked sponge cakes, still in their trays, then pass through a cooling chamber. Tilting the trays at an angle facilitates the removal of the cakes, which are then wrapped and automatically packed. The trays continue on their travels, during which they are washed with high pressure jets of hot water and then dried in an oven before reaching the greasing station already mentioned.

For such a plant, producing 25,000 sponge cakes per hour, to work continuously without costly stoppages, it was necessary for detailed study to be made of each operation. The choice of a suitable lubricant for the endless chains being successively heated, cooled and sprayed with hot water was a relatively simple matter, but the prevention of the sticking of the cakes to the trays was far from simple. It was not only necessary that the cakes should be easily removable from the trays, but also that no trace of the sponge should remain behind, otherwise the cleaning of the trays for the next cycle would become increasingly difficult. The greasing mixture must not only form a continuous film over the metal, but it must be of such a consistency that on entering the oven it does not run and form a puddle in the depressions in the trays. The consistency of the fat used clearly had to be kept within fairly close limits, but the problem was

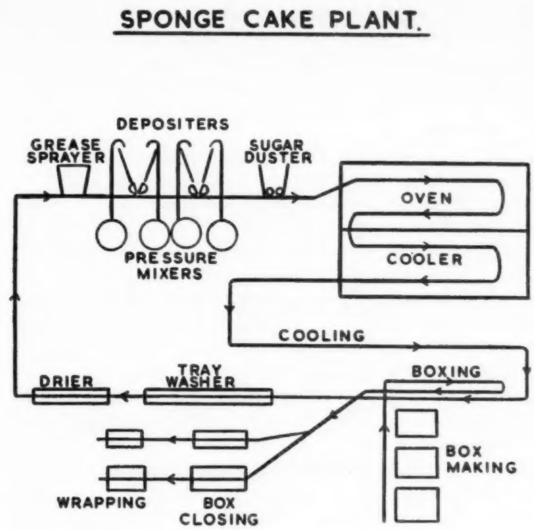



Fig. 8. Diagram of sponge cake process.

much simplified when epoxy resin coatings for metals were developed and applied to these sponge cake trays.

### *ingredients*

The control of the ingredients in the sponge mixing is, of course, of fundamental importance. This includes testing the aerating properties of the egg, the physical properties of the flour, the rate of reaction of the baking powder and the particle size of the sugar. All these are of interest, but I propose to confine myself to a very short reference to two instruments designed to assess the physical properties of flour.

The Farinograph is a device for mixing flour and water to form dough under controlled conditions, and for measuring and recording the torque developed by the dough during the mixing process. A typical curve obtained with this instrument is given in Fig. 9. This

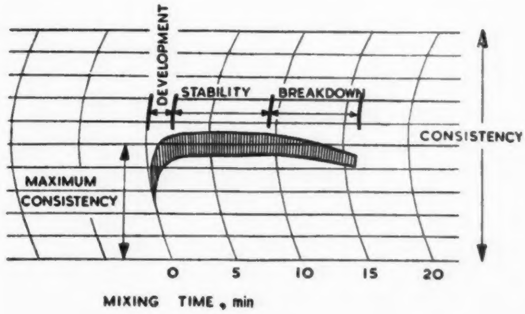



Fig. 9. Farinograph curve.

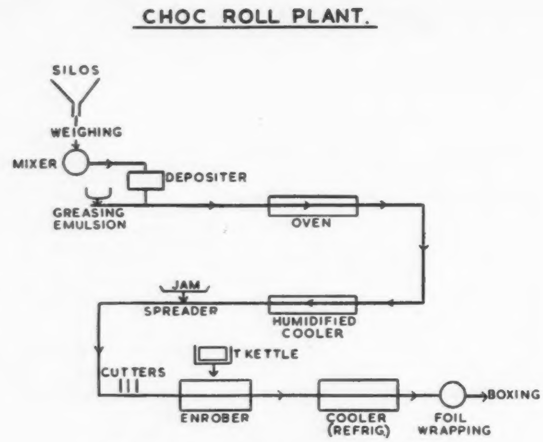



**Fig. 10. Diagram of Choc Roll process.**

illustrates the increase in consistency of the dough during the "development" stage, namely during the period that the protein of the flour is hydrating. The "stability" of the dough is indicated by the time it maintains its maximum consistency during the mixing process.

A somewhat different property of dough may be measured by use of an Extensograph. A dough-piece prepared in the Farinograph mixer is placed in the Extensograph which rolls and shapes it in a standard manner and then, after allowing a resting period, the dough-piece is stretched to breaking, while recording the "extension" and the "force" required to extend it.

From the empirical but nevertheless controlled tests by such instruments as the Farinograph and Extensograph, it will be appreciated that one can choose a flour having the appropriate physical properties for different products and suitable for the mechanical plant available for their manufacture.

In the above remarks, particular stress has been laid on the physical properties of ingredients and therefore it is appropriate to mention that a final check of the resulting texture of bakery products can conveniently be obtained by photographing a cross-section of such products. From such records, taken at monthly intervals, of different batches of the same product, changes in quality which may be unnoticed by bakery operatives and supervisory staff may be detected.

## *Choc Roll manufacture*

The manufacture by a continuous plant of small Swiss Rolls, enrobed with chocolate couverture, is illustrated diagrammatically in Fig. 10. The process bears some resemblance to the sponge cake process, in that similar ingredients are pressure-mixed and deposited. In this case, however, the mixture is deposited on to a previously greased steel band which conveys the mixture through a continuous oven, thereby producing a band of baked sponge which then travels through a humidified cooler. The sponge after cooling is spread with a jam or buttercream filling, automatically cut (Fig. 11), rolled, enrobed with chocolate, cooled to allow the chocolate to set, and packaged.

As in the manufacture of sponge cakes many controls throughout the process are necessary. These include the consistency of the greasing mixture on the steel band, the aeration of the sponge mixture, the cooling of the baked band of sponge which needs to be effected in a humidified atmosphere to prevent cracking when rolled and, of course, all temperatures; if the temperature of the chocolate used for enrobing rises significantly, the texture and appearance of the final product will suffer.

## microbiological aspects of Quality Control

It is quite impossible to give a reasonable coverage of the various aspects of Quality Control in food preparation without devoting some attention to the microbiological viewpoint. In doing so, it is not proposed to dwell on methods of destroying micro-organisms by heat treatment or means of preventing subsequent contamination, as for example in the manufacture of ice cream, but rather to consider the control of conditions in order to minimise microbiological deterioration of products.

Amongst the factors limiting the growth of bacteria, yeasts and moulds is the osmotic pressure of the medium on which they grow. Attempts have therefore been made to devise a method by which osmotic pressure, or other physical property related to it, may be determined as a measure of the likely rate of microbiological growth in a food product and therefore of the keeping properties of that product. Such a method is the determination of water vapour pressure. When a product has come to equilibrium with the air surrounding it, i.e., when no further transference of water to or from the product occurs, the water vapour pressure of the product and that of the surrounding air are equal. The water vapour pressure of the surrounding air, normally termed the "equilibrium humidity" of the product, is therefore a measure of the microbiological factor required.

A routine method of determining the equilibrium humidity of foods, normally expressed as percentage Equilibrium Humidity (E.H.), is to place the food in a closed vessel until equilibrium between the food and the air in the vessel has been established and then to determine the dew point of that air. By such a mean it has been shown that development of yeasts and moulds are mostly inhibited at E.H. of 70 - 74%, but for complete suppression of growth an E.H. as low as 65% is necessary.

Other factors which limit microbiological deterioration in a product are temperature (both high and low), acidity (pH) and of course the presence of preservatives. When, therefore, one studies the keeping properties of a product, particularly from the microbiological viewpoint, it is necessary to take advantage of one or more of the above-mentioned inhibiting factors appropriate to the product under consideration. Normally one applies heat to destroy

organisms present and maybe to remove some water in order to reduce the E.H. of the product. The acidity may be increased if flavour will allow, and the temperature of storage reduced if the composition of the product will not otherwise prevent the development of adventitious organisms. Preservations are only added in limited quantities to specified foods. When considering the composition of a product, particularly in relation to its acidity or its sugar content (usually the factor determining E.H.), it is important to remember that it is the composition of the aqueous (non-fatty) phase which is important, for it is that which largely determines the growth of bacteria, yeasts and moulds.

An example in which the above general principles have been applied is in the manufacture of Christmas puddings, in which the product is cooked by steaming and then dried. By ensuring that the drying operation results in a product of sufficiently low E.H., one can ensure that mould growth during a long period of storage will be prevented.

Amongst the more intransigent products are those which will not permit of an initial heat treatment, as, for example, mayonnaise which consists essentially of oil and vinegar emulsified with egg yolk. One cannot reduce its E.H. by adding sugar for reasons of flavour, so consideration is given to the acetic acid (vinegar) content of the aqueous phase. To destroy pathogenic organisms a concentration of approximately 0.5% acetic acid (or pH 4.5) is required in aqueous solution, but for complete suppression of yeasts, moulds and lactobacilli, a concentration of 3.6% acetic acid may be necessary. In mayonnaise dressings a compromise is normally adopted by ensuring an acetic acid concentration in the aqueous phase of not less than 1 - 1.5%. This ensures the destruction of pathogens and arrests the development of harmless organisms, but does not necessarily cause their complete destruction. As a consequence the product has limited storage properties.

**moisture transference and packaging**

Moisture content, or more particularly percentage E.H., has been shown to be be an important factor affecting quality of some food products. Increase of moisture content of such products may result from moisture uptake from the atmosphere or from some other parts of the same product. In both cases, packaging may be a factor.

For example, one might instance the wrapping of a fruit pie. During storage moisture passes from the filling to the pastry and if the pie is in a moisture-proof packing, the pastry will lose its crispness and mould growth will occur. Some evaporation of moisture from the surface must be allowed to continue to balance the moisture diffusing from the centre. The fruit pie has a relatively large reserve of moisture in its filling, so a moderate drying out within the normal life of the freshness of the pie would not be serious.

This transference of moisture can be prevented by so altering the composition of the various parts of a product that they have the same percentage E.H. Then a moisture-proof wrapping may be used. Such a change in the composition is only possible in a limited number of cases as, of course, it is liable to change the character of the product. An example of the application of this principle is the preparation of packages or " iron " rations used during the War and more recently for Arctic and other expeditions.

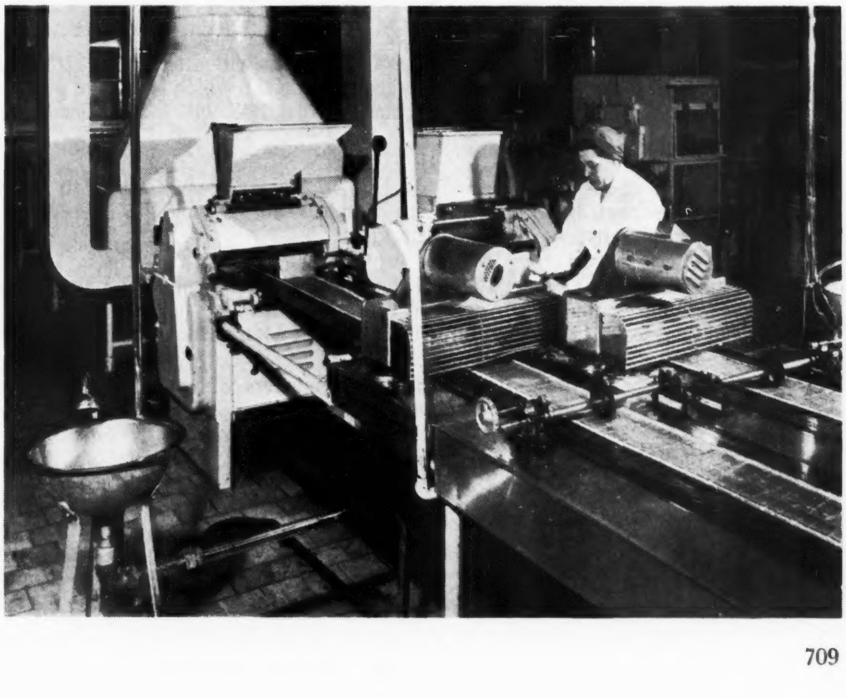


**Fig. 11. Spreading and cutting of the sponge (Choc Roll).**

The packages were required to contain a variety of items which had widely differing E.H., with the result that during storage moisture passed from those with the higher to those with the lower E.H. The composition of certain of the products was suitably modified, with the result that deterioration previously caused by moisture uptake during storage was eliminated.

One final exercise on the moisture transference problem in relation to packaging, concerns a small cake in a fluted paper container and with surface icing. This product was very susceptible to changes in atmospheric humidity. Moist air caused the icing to become sticky or almost fluid ; dry air caused the icing to become hard and dry and eventually the cake portion to be toughened. The use of a moisture-proof wrapping was quite ineffective in preventing this as moisture from the cake passed through the paper case, raised the humidity of the air inside the wrapper and hence made the icing sticky.

The complete solution of this problem involved changes in the container, in the composition of the icing and of the cake. The E.H. of the icing and of the cake were adjusted to minimise moisture interchange, but the E.H. of the cake was subject to the variation normally experienced in a baked product of that type. As a result, some moisture transfer still occurred but mostly from the cake through the paper case to the icing. By baking the cake in a laminated container having a moisture-impervious layer of aluminium foil, the moisture transfer was limited to the surface of cake in contact with the icing. As the rate of transfer there is very slow indeed, a considerable freedom of choice of wrapping materials became possible.

**conclusion**

Although the assessment of the quality of food in terms of palatability is still, and presumably will continue to be, a personal matter, the control of that quality has already to a large extent become a function of science.

The examples of food Quality Control which have been described have demonstrated the application of relatively simple scientific principles. Modern developments, particularly in chemistry and physics, are already pointing the way to a vast field of study in the development of further refinements in methods of food Quality Control.

The author's thanks are due to the Directors of Messrs. J. Lyons and Company Limited for permission to publish this Paper.

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# INTERNATIONAL CONGRESS OF SCIENTIFIC MANAGEMENT

## AUSTRALIA, 22nd February - 4th March, 1960

It is expected that between 1,600 and 2,000 delegates will attend the 12th International Congress of the International Committee of Scientific Management (CIOS), which is to take place in Australia early next year, and representatives from the 29 member countries of CIOS will include leaders of industry, commerce and Government.

The first part of the Congress will be held in **Sydney** from **22nd - 26th February, 1960,** and the second part in **Melbourne** from **29th February - 4th March, 1960.** During the intervening weekend, parties will visit the Snowy Mountains hydro-electric undertaking.

It is anticipated that a strong United Kingdom delegation will attend the Congress and arrangements are being made for charter flights to Australia. Further details may be obtained from Mr. B. W. Vigrass, Head of Regional and Overseas Department, British Institute of Management, 80 Fetter Lane, London, E.C.4.

**Members of The Institution of Production Engineers who will be attending the Congress are asked to advise the Secretary, who will also be present.**

# THE CONTROL OF QUALITY IN THE HOLLOWARE INDUSTRY

by **N. R. Worrall**, A.M.I.E.I., F.R.S.A.

Consultant Inspection Engineer

A HOLLOWARE firm in the Midlands had for many years enjoyed the reputation of producers of fine enamelled holloware. A number of localised factors accounted for this, but mainly it was because the Midlands, and more especially the Black Country, has always allowed its female population to furnish a large proportion of the labour force. Cradely Heath is a town where employment of women is restricted owing to the preponderance of heavy industry such as chain-making, anchor forging, crane and hoist manufacture, to mention but a few. This firm, then, provided employment for women, and although classed as light engineering, it should be pointed out that the work involved in the hand-dipping of articles is, in fact, heavy. Also, transport was less well distributed and the opportunities of work in Birmingham were considerably fewer than nowadays. It is possible that these factors alone were enough to a labour force willing to learn and able to withstand conditions not conducive to constant production.

From the point of view of male employment, the work consisted mainly of supervisory duties on the engineering side; that is, the setting and maintainence of machinery. Engineering and supervision remain fairly constant with regard to the capabilities required, and thus apprentices, foremen and engineers were evenly distributed over the area's available industries.

Changing circumstances considerably altered these conditions and with the swing to a labour force market, the Factory Act, Trades Unions, and increase in transport facilities, and the rise of more industrial undertakings, an employer was no longer in a position to neglect working conditions or payment. Furthermore, technological advances had put faster production methods in an employer's hands, and to remain static in this field would reduce a firm's chances of survival to nil. A greater movement in labour forces meant that machines had to process faster to make up for the deficiencies inherent in what was now a fluctuating, semi-skilled group of employees. While supervision had to increase its watchfulness, it was impossible for a firm to engage supervisors to keep pace with the rise in production with its consequent rise in the number of defectives produced. The firm concerned decided that the only way to maintain production and lower the costs of supervision and rejected work was to introduce Quality Control.

At the same time, Work Study was introduced to systemise the work done with a view to maintaining production with the labour force available. The approximate distribution of labour in the works at the time was :-

| | |
|---|---|
| Unskilled — fairly static | 37.5% |
| Semi-skilled — fluctuating | 50% |
| Skilled — with a tendency to decrease | 12.5% |

It is interesting to note that of the unskilled, trainee and semi-skilled groups, an indifference to quality of product was marked and a certain mistrust of new methods was common to all. The figures quoted, as well as the above observations, do not include the supervisory staff.

### immediate problems

The problems were, in point of fact, multifarious, but so interdependent on one another that they could be boiled down to the following :-

(a) to convince the shop floor of the need for better quality;
(b) to convince them that the new schemes would raise the standard without direct interference in their work;
(c) of a technological nature — to define the assessment of quality;
(d) to draw up a pilot scheme that would furnish data which was not in existence prior to the introduction of Quality Control — this pilot scheme must, perforce, satisfy the requirements of (a) and (b) and also be capable of expansion rapidly but surely;
(e) to introduce a set of visual and written standards, also not previously in existence;
(f) to increase the co-operation between departments;
(g) to eradicate those faults which were due, in the main, to negligence and mishandling and which were largely uncontrollable from a statistical point of view.

Of this latter item, by far the most important fault was dents. A dented article is an article which is unsightly to the customer, however beautifully enamelled it may be. Before control was instituted, the number of articles dented and passing through a rectifying department from which more or less accurate returns were made, was in the order of 80% of all articles produced. An unspecified number of accidents occurred in the transport of articles either between departments, in dobbins, or from badly loaded conveyor tracks, resulting in continually fluctuating departmental returns, although not actually affecting end output. Clearly, productivity was affected by what may be summed up as the psychological attitude of the working staff, and statistical side-issues having little bearing on controllable quality. Marching side by side with what was proposed, the eradication of dents would be necessary in order to build up the prestige of a new department which was viewed by most as another newfangled idea that would die a speedy death.

**the pilot and its results**

It was observed, during the time that personally collected data was being assessed, that there was a tendency to blame the department known as Electric Welding for a high proportion of the accumulated dents in articles proceeding from this point. It appeared that this department might benefit from a boost in morale, and since the department immediately following was the only reasonably reliable check point for defects within the organisation, the Electric Welding department was chosen as the scene for the first activities.

The production set up consisted of a number of welding rigs, filing points and grinding and reaming jigs, placed around the oval conveyor track. A dobbin of work was drawn up at the side of the operator, who, having completed his or her operation, placed the article on the conveyor track for the attention of the next operator. Also situated on this track was a female operator whose function was to remove the finished article, examine it perfunctorily and load it into the dobbin. A chart was drawn up and clipped to a board mounted on a stand, and the operator was asked to load her dobbin according to the following instructions:-

(i) remove articles from track and examine in the normal way;
(ii) at the same time select at random and set aside 25 articles until the dobbin with these 25 articles should be loaded;
(iii) thoroughly examine the "sample" of 25, noting on the chart the fraction defective possessing "bright dents". A "bright dent" was universally agreed to be a dent that was obviously made after the pickling process. This fact was very important in the light of further investigations, drawing a sharp line between those who could be blamed and those who were blameless.

The result of this chart was to interest first the examiner, and then the surrounding operators, and finally the whole shop. Misgivings were discussed and the change in attitude can be traced in the graph (Fig. 1). It was observed also that the height of the machines in relation to the edge of the track was such that it was possible to bash the article on the edge of the track when production was in full swing. As discreet observation of their methods was con-

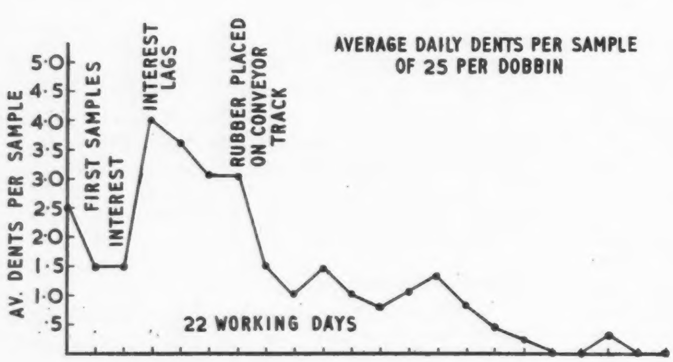


Fig. 1.

## SNAG LIST

Appendix No. 3

Fig. 2.

| DEPT | FAULT | COLOUR CODE Master Chart | COLOUR CODE Control Chart |
|---|---|---|---|
| $f = 20$ UNITS PER HOUR 12 M/C's BLANK & CIRCLE | INCORRECT SIZE | BROWN | 2 |
| | ,, THICKNESS | YELLOW | 3 |
| | SCORING & BUCKLING | BLUE | 4 |
| $f = 20$ UNITS PER HOUR 18 M/C's DRAW PRESS | LAMINATIONS | BROWN | 2 |
| | SPLITS | YELLOW | 3 |
| | RIBBING | BLUE | 4 |
| | WRINKLED FLANGES | ORANGE | 5 |
| | TOOL MARKS (SCORING) | PURPLE | 6 |
| | DENTS | RED | 9 |
| $f = 10$ UNITS PER HOUR 110 M/C's SPOUT & HANDLE COVER | BURST COVERS | BROWN | 2 |
| | TOOL MARKS | YELLOW | 3 |
| | SPLIT WELDS | BLUE | 4 |
| | ,, NOSES | ORANGE | 5 |
| | ,, FLANGES | PURPLE | 6 |
| | BAD OPERATION | MAUVE | 7 |
| | DENTS | RED | 9 |
| $f = 10$ UNITS PER HOUR 49 M/C's SPIN, CROP, BEAD SHOPS | SPLIT BELLYING | BROWN | 2 |
| | ROUGH PIERCING | YELLOW | 3 |
| | BAD NECKING | BLUE | 4 |
| | SHORT BEADING | ORANGE | 5 |
| | CRUSHED ,, | PURPLE | 6 |
| | FRAZE, DENTS | MAUVE, RED | 7 & 9 |
| $f = 20$ UNITS PER HOUR 5 FURNACES 2 PLANTS SCALE & PICKLE | SCALE & RUST ADHERING | BROWN | 2 |
| | SAMPLED DENTS INCOMING (CHECK) | YELLOW | 3 |
| | ARTICLES DENTED IN DEPT. | BLUE | 4 |
| $f = 10$ UNITS PER HOUR UP TO 18 POS. GAS WELDING | BAD WELDING | BROWN | 2 |
| | ,, FILING | YELLOW | 3 |
| | BAD OP. ON THE TWO M/C's | BLUE | 4 |
| | DENTS | RED | 9 |
| $f = 20$ UNITS PER HOUR 39 M/C's ELEC. WELDING | BAD GRINDING, REAMING & FILING | BROWN | 2 |
| | BAD WELDING | YELLOW | 3 |
| | OPERATIONAL FAULTS | BLUE | 4 |
| | BRIGHT DENTS | RED | 9 |
| 10 RECTIFIERS + FOREMAN DENT RECTIFICATION | 100% INSPECTION & RECTIFICATION OF DENTS } $\Sigma$ ON DATA SHEET | | |
| DRIERS 10 UNITS/HR. EACH ARTICLE | PERRIT POINT MARKS | BROWN | 2 |
| | DUST & GRIT | YELLOW | 3 |
| | WATER MARKS | BLUE | 4 |
| | SPLASHES | ORANGE | 5 |
| | RUNS | PURPLE | 6 |
| | MISSED PATCHES | | |
| | THICK BISCUIT | MAUVE | 7 |
| | DENTS | RED | 9 |
| FURNACES 2 off 10 UNITS/HR. EACH ARTICLE | BLOW HOLES & BLISTERS | BROWN | 2 |
| | CRAWLING & TEARING | YELLOW | 3 |
| | CHIPS | BLUE | 4 |
| | DENTS | RED | 9 |
| | THIN BISCUIT | ORANGE | 5 |

FINAL SUPERFICIAL
100% INSPECTION BY PACKING

tinued, it was found that the operators bashed them at every opportunity. Clearly methods experimentation could not be indulged in at this stage, so the suggestion that the edge of the whole track was padded with rubber to absorb some of the shock, was implemented. This had the immediate effect of lowering the "average daily dents per sample" and the graph line suffered a decline. Next there was introduced on the chart a control line which was altered every week and the news spread through the shop that a red line had been put on the chart. This aroused great interest, in spite of the esoteric attitude of the one and only examiner, who considered herself the high priestess of Control Charts! As the number of dents dropped off, the control line was dropped until finally the number being charted was so low as to be no longer controllable.

An interesting statistical sidelight emerged when the random samples expressed percentage defective were accurate to within 2% on 100% examination in the Dent Rectification Department.

A great deal had been learned about psychology, if only a little about the Control of Quality.

### the system

The following is really a brief outline of the charts devised :

### *the data sheet*

An accurate return was required of the type and number of articles rectified in the "Denting Department", as opposed to the number they were issued with.

CHART FAMILY TREE

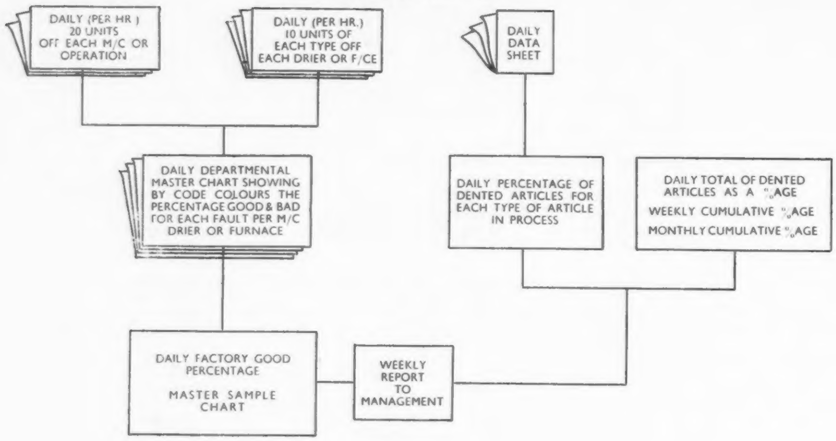


**Fig. 3.**

### *the " 20 units per hour " and the " 10 units per hour " charts*

The fraction-defective charts were designed to suit the needs of the two main departments of the works. They were used for the Prefabrication group of shops and the Enamelling group, and were sampling in the region of 5 - 6% of the production. The two charts actually embodied a refinement that not only measured the fraction-defective, but by a series of numbers along the bottom horizontal axis, indicated how the whole fraction broke down. By way of explanation, I would point out that a great number of pieces during production could, and frequently did, at the beginning of Control, attain the distinction of as many as eight faults per piece! In order to eradicate the faults, it was necessary to spend a great deal of energy on collecting statistical information, and the provision for the recording of these faults was made by allotting each charting point a coded list of snags. This list may be examined in Fig. 2.

### *master charts*

Master charts for each section in the two departments were held in the Control Office, and the control charts were collected and analysed each day on to the masters. Fig. 3 shows the " family tree " of charts used above.

### the production method

In order to show the set-up from the production point of view the production of a kettle from a blank to finished article is now described. Fig. 4 shows a production flow diagram which, if studied in conjunction with the script, gives a typical manufacturing system within the works.

Body, spout, handle and cover are manufactured separately throughout Prefabrication up to the Electric Welding shop and the cover, after scaling and pickling, is sent direct to the Enamelling Department, where it receives two coats of enamel, has its heat-resisting kob riveted on and is packed with the finished kettle.

The body is blanked out in a circular shape and checked for dimensions and quality of steel. It is then drawn into a cylinder, necked under a set of gas jets, has the skirt cropped off, and the spout filter pierced in the side. It is scaled and pickled and sent to Electric Welding for assembly to the handle and spout.

The handle is blanked, pierced — that is, the ends are shaped, coaxed, 'U'd and closed into a cylinder, filled with steel shot and bent — the end of the seam is locked over and welded fast, the flange is set up on the ends and the whole is set into the correct form. Similarly, the spout passes through various processes concerned with its shaping and is then sent to the Gas Welding department for the seam to be welded. This, like the handle, is a one-piece unit. The handle and spout is now passed through the scaling and pickling plant and forwarded to Electric Welding.

After assembly, the kettle is examined thoroughly in the Dent Rectification shop and any necessary repairs carried out.

The article is now in the Enamelling Department. A " dipper ", as the operator is called, whose pan of liquid enamel stands at the side of the drier and its conveyor belt, selects the kettle and dips it into the liquid. With a motion peculiar to this trade the kettle is turned swiftly by hand tongs and then hung by its handle on perrit points on the track. The quality of the article depends entirely on the operator at this point, as no complete visual examination is possible.

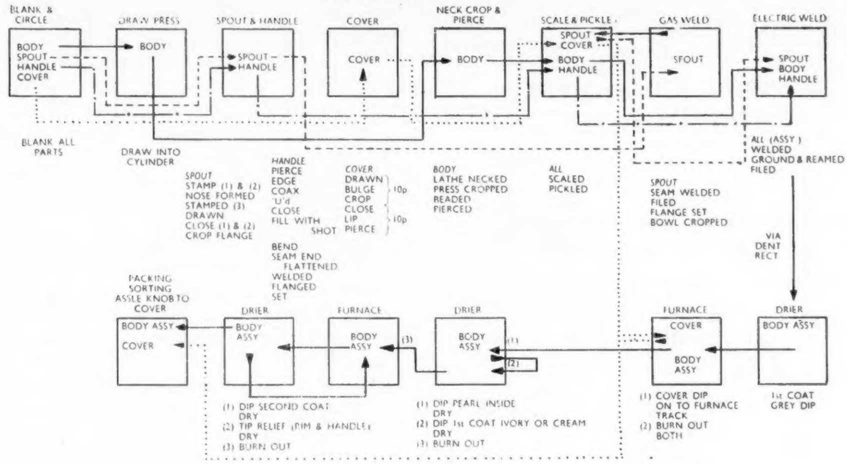


**Fig. 4.**

The track moves into the furnace and on emergence may be handled. This is known as the biscuit stage. All faults are now visible and after charting in the various codes, the unloaders remove the units from the track. The inspector acquaints the foreman of any deviation from the norm with an assignable cause which can be remedied at its source, and the work continues. Such deviations are cyclic and usually due to fatigue on the part of the dipper. It is emphasised that the nature of the operation is such that fatigue sets in swiftly, but following excellent research work done by Work Study under

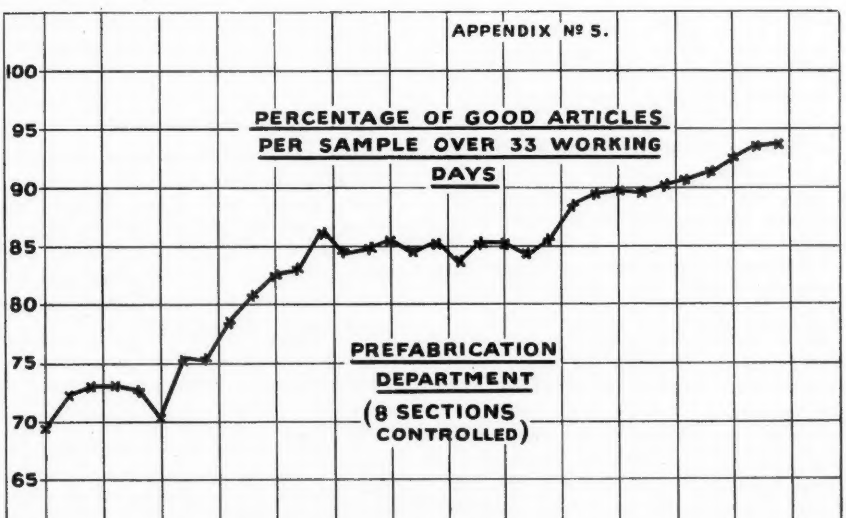


**Fig. 5.**

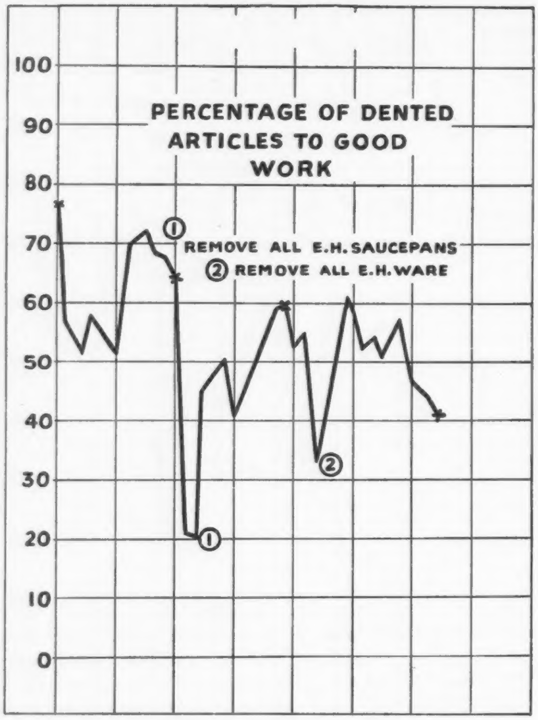


Fig. 6.

Quality Control conditions, it has been possible to set the frequency of observation in accordance with this known phenomena, adjusting the sample size to match differing production quantities.

The unit is now loaded on to the furnace track and burned out. This process fixes the first coat grey dip and it emerges as a black shining surface. It is now dipped on another track in this way. First the inside is dipped in the " pearl " enamel, dried out in the drier, and the outside dipped first coat colour. The whole is burned out in the furnace and the unit sent to the second coat dip, then dried.

The handle and rim is now accepted by the " tippers ", who put on the relief colour. Only the most skilled operators are allowed to do this operation and consequently the standard is very high.

The kettle with second coat colour and relief is burned out in the furnace and examined, charted for information, accepted or rejected and packed.

With Quality Control in the shops previous to the Dent Rectification stage, it was found that the number of dents had dropped from nearly 80% of the total production to 40% in 33 working days. The graph in Fig. 5 shows the rise in quality of all the shops over the same period. It was found possible to bypass the Dent Rectification shop with certain articles as forces were concentrated on this problem. The covering of the edge of the conveyor track with rubber reduced to negligible proportions the number of dents in the Electric Welding department. After 12 working days no extra-heavy saucepans required examination beyond the routine samples, and after 23 working days no extra-heavy ware at all required attention beyond the normal routine. Frypans were shortly taken out and all collected data was continually under review with the " by-passing " under consideration (Fig. 6).

The Dent Rectification department, which employed a large number of operators, was also exhaustively investigated and, in the light of the improvements, it was possible to rechannel half of the staff. Two lights were installed in order to obviate the necessity of rubbing down each unit. The two lights were swivel-mounted inside the two darkened booths and two counters were mounted on the outside structure. The light was fitted in such a way as to throw into sharp relief any dents in the article rotated beneath it. (See Fig. 7 for an illustration of the set-up.) The dents observed were ringed with chalk, and the article was passed to the operator for rectification. This had the tendency of making redundant helpers engaged in the old method of emery-clothing off the soda deposit in order to bring the dent into relief. However, the one or two helpers per operator were kept on until the examiners at the booths had attained sufficient speed to obviate the necessity for rubbing down. There was no question of their being left without a job, as the need for personnel on the dipping lines had increased tremendously. Work Study had reviewed the wages, and the incentive under piece rate conditions was a big factor in the re-channelisation of labour.

## use of films and cartoons

A number of films were shown in the canteen outlining the broader issues of Quality Control and Work Study, and these, though few in number, greatly assisted in putting over the idea behind the new systems. A cartoon feature was also used to draw attention to these ideas, and enjoyed a modicum of success when exhibited on the notice boards.

The main theme of subjective assessment that was the key to the Control of Quality within the organisation continually presented problems. With co-operation these problems will, in future, be largely solved.

A word about the inspectors; these men were former supervisory staff, and as such, had the trust and respect of operators and of management alike. It is largely due to them and their foresight, as well as their experience, that Quality Control was made to work in an industry where no critical dimensions existed for statistical control in the accepted sense.

When the Control Scheme was in full working order, for the first time, Inspection was engaged in preventing defectives, and as such realised the true aim of Quality Control, which is to be a tool in the hands of production.

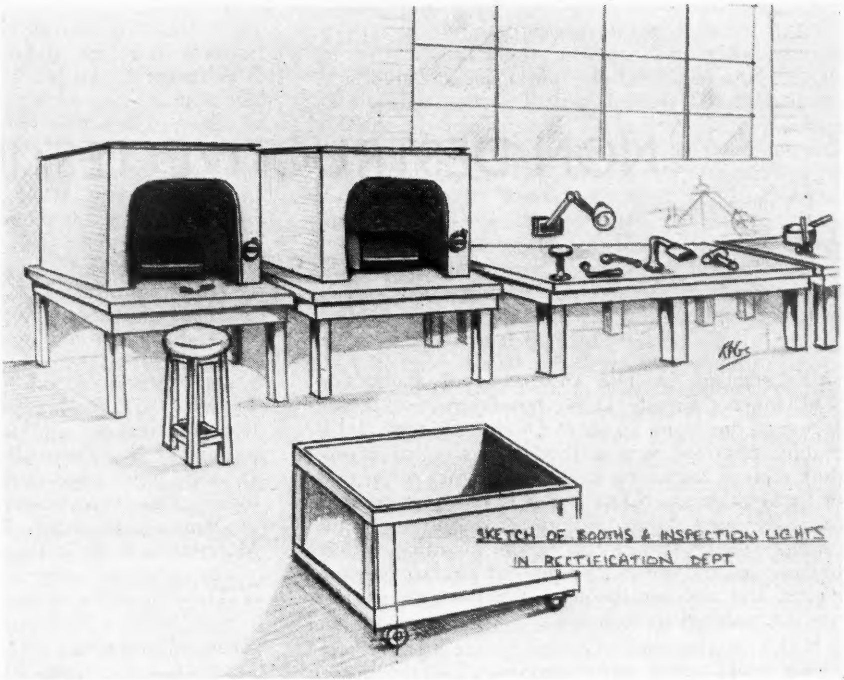


Fig. 7.

# DIARY DATES FOR 1959-1960

**December 10th** ... **The 1959 Sir Alfred Herbert Paper,** at the Royal Institution, London.
Speaker: **Dr. D. F. Galloway,** Director of PERA.
Subject: **"Production Engineering Developments in Russia."**

**January 29th, 1960** ... **The Annual General Meeting** (see Journal Supplement).

**March 17th** ... ... **The 1959 Viscount Nuffield Paper,** at the Rankine Hall, Institute of Engineers & Shipbuilders in Scotland, Glasgow.
Speaker: **Dr. C. Timms,** M.I.Prod.E.
Subject: **"Recent Developments in Spur and Helical Gears."**

# NON-DESTRUCTIVE TESTING

A report by **C. C. Bates,** M.I.Prod.E.

As members of The Institution of Production Engineers already know, non-destructive testing is one of the many facets of Quality Control and is readily described as a method of examining a product without impairing its use, its physical properties or its functioning. N.D.T., as it is known in brief, is regularly used by a variety of industries, some examples being the control of the quantity of beer in cans, the routine examination of aircraft between flights, and the regulation of the thickness of fast moving material in strip mills.

N.D.T. is also regularly used by the medical profession in diagnosing and controlling illness or disease. Similarly, production engineers are using it to increase production as well as to control quality. By the use of radiation emissions, instrumentation and ultrasonic waves, to mention a few applications, the production engineer is not only reducing his rejects at the output end of the line, but he is also controlling the manufacture and sorting of the basic raw materials, thus producing more consistent material for manufacture and subsequent control processes.

### a central clearing-house

The British National Committee for Non-Destructive Testing, which is a body representing all the major Institutions, acts as a central clearing house and co-ordinating centre for all Institutions and Technical Societies interested in this process, and was formed following the visit of a number of engineers to the First International Conference on Non-Destructive Testing in Brussels in 1954. The British engineers who attended this Conference realised, not for the first time, their diversity of interests and, simultaneously, the lack of co-ordination and concerted effort in Britain as compared with Continental countries. After the Brussels Conference, and in the knowledge that the Second International Conference was to be organised in Chicago two years later, some members of a Society which was directly and intimately concerned, arranged for an approach to be made, with the Institute of Physics, to The Joint Committee on Materials and their Testing. This latter body agreed to act as a post office for a period of 12 months. In January 1957, the necessity for a separate organisation was realised and The British National Committee for Non-Destructive Testing was established. It was fully appreciated that whilst being an independent body, it must also collaborate and work in conjunction with The Joint Committee on Materials and their Testing.

The terms of reference, objects and constitution of The British National Committee are as follow :-

### terms of reference

Provided that it shall not be allowed to absorb or replace the activities of any existing Institution or Society, but by agreement might appropriately supplement such activities, The British National Committee for Non-Destructive Testing has been formed by the agreement and co-operation of Technical Institutions and Societies and The Joint Committee on Materials and their Testing, to act in all technical matters relating to non-destructive testing.

### objects

(a) To promote discussion.

(b) To assist a co-operating Institution or Society in the presentation of a Paper or a group of Papers concerned with non-destructive testing.

(c) To undertake those duties with respect to international matters which properly devolve on the National Committee, which may include the nomination of delegates to represent the United Kingdom at international meetings and the initiation of proposals or questions for discussion at those meetings.

(d) To collect and administer funds for the purpose of carrying out the above objects.

### constitution

Members of the British National Committee will be drawn from three sources :

(i) Representatives of constituent Institutions and Societies of the Joint Committee on Materials and their Testing.

(ii) Representatives of other Institutions and Societies interested in non-destructive testing.

(iii) Individual experts co-opted by the National Committee.

*Mr. Bates represents the Institution of Production Engineers on The British National Committee for Non-destructive Testing.*

After its formation The British National Committee, supported by most of the major Institutions, not only appointed three official British delegates to speak on behalf of Britain at the Second International Non-Destructive Testing Conference, held in Chicago in November, 1957, but also arranged a meeting of most of the British representatives who intended to be in Chicago. It was gratifying to note at the International Conference the serious attention given to the contributions made by British delegates.

The present membership of The British National Committee comprises some 23 Institutions and, as will be seen, The Institution of Production Engineers plays a prominent and active part in that its representative was appointed as one of the British delegates for the 1957 Conference.

The British National Committee in no way attempts to interfere with the activities of the Institutions and Societies which are its members; rather does it tend to act as a central clearing house and co-ordinating centre. The broad function of the Committee is that if a member Institution or Society, through its delegate, mentions the need for a Symposium or Conference dealing with a particular aspect of non-destructive testing, of interest to one or more other member Institution and/or Society, it requests the organisation of such a symposium or conference with the assistance of such other interested bodies. It then arranges the circulation of this information to all member Institutions and Societies, so that as wide publicity as possible is given. This also prevents duplication of a symposium or conference by two or more Institutions or Societies.

The British National Committee, through a Sub-Committee, has also organised and arranged for Schools and Weekly Conferences on the broader aspects of non-destructive testing. A recent instance of its work in this connection is its sponsorship of The Summer School on The Principles and Practice of Non-Destructive Testing, held at The Manchester College of Science and Technology in September, 1958. This Course was organised by the College in association with The Manchester Association of Engineers and The Institution of Engineering Inspection. Adequate proof of the demand for such a course was given by the fact that it could have been filled three times over, so that The British National Committee arranged to sponsor a further series of courses through various technical colleges and universities throughout the country.

A further problem which must of necessity occupy the minds of engineers, but which cannot be dealt with by any one Institution or body, is that of the needs of industry. In tackling this very wide and complex subject The British National Committee is proving the necessity for its existence, by discussing and collecting material from representatives of various branches of industry and its member Institutions and Societies, so that a study may be made of existing knowledge and future requirements made known. In due course, when this information is available, the Committee may be in a position to advise Institutions, technical colleges, universities and research associations what fields of research and investigation will be most useful to British industry as a whole.

Therefore, not only does membership of The Institution of Production Engineers give support to The British National Committee but also, individual members, through their delegate, can raise and have matters of national interest discussed in a very wide engineering sphere.

## INTERNATIONAL CONFERENCE ON HEAT TRANSFER

The Institution of Mechanical Engineers, jointly with the American Society of Mechanical Engineers, is planning to hold a Conference on Heat Transfer, in the United States in August, 1961, and in Britain in 1962.

It is hoped to obtain about 100 short Papers on all aspects of heat transfer, which will be presented and discussed on both sides of the Atlantic.

Further details of the arrangements will be announced as they become available.

*Written discussion on Papers appearing in the Journal, or comment on any subjects of interest to production engineers, is invited for publication in the Journal. Contributions should be addressed to*

*The Editor, 10 Chesterfield Street, Mayfair, London, W.1.*

# institution notes

## VICE-PRESIDENT TO SPEAK AT CAREERS FESTIVAL

Mr. Harold Burke, Vice-President of The Institution, is one of the speakers at the Careers Festival which is to take place in Birmingham at the end of this month and the beginning of January, 1960.

The Festival is being organised by The City of Birmingham Education Department, through their Youth Employment Committee, with the object of supplying information to young people who have reached the stage of choosing a career.

Mr. Burke will give an address on "Careers in Production Engineering" at The Midland Institute, Paradise Street, Birmingham, on 1st January, 1960, at 2.30 p.m. The other speaker at this meeting will be Mr. J. E. Belliss, Chairman of the Midland Branch of The Institution of Mechanical Engineers, whose subject will be "Careers in Mechanical Engineering".

## SHEFFIELD SECTION DINNER

**The Sheffield Section Annual Dinner, which took place on 12th October last, was as usual a highly successful and well organised function. This photograph, showing the Section officers with the principal guests, includes (left to right) back row: Mr. R. W. Asquith, M.C.; Mr. C. F. Rose; Mr. H. Crompton; Mr. R. Shilton; Mr. C. H. T. Williams; Mr. Ambrose Firth. Front row: Mr. S. B. Rippon; Mr. H. C. Johnson, O.B.E.; Mr. G. Ronald Pryor, President of the Institution; The Lord Mayor of Sheffield (Alderman A. V. Wolstenholme, J.P.); and Mr. W. B. Siddons.**

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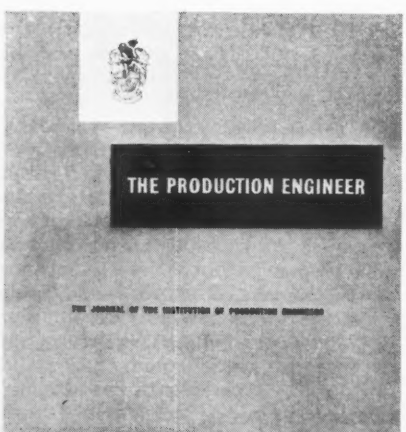


## A NEW LOOK FOR THE JOURNAL

**Members are reminded that with the January, 1960, issue the Journal of The Institution appears for the first time with a specific title, "The Production Engineer" and a new cover design, which is reproduced on the left. Changes in presentation will also be noticed in the editorial content of the Journal, and in the Supplement. An article by the Chairman of the Editorial Committee, in the January issue, explains the thinking behind this restyling and outlines the future policy of the Committee.**

# The President's Visit to Poland

**Mr. G. Ronald Pryor reports on his recent tour**

I RECENTLY had the privilege of representing The Institution of Production Engineers at a Conference in Cracow to celebrate the 10th Anniversary of INSTYTUT OBROBKI SKRAWANIEM (The Institute of Metal Cutting).

The Conference, which attracted an attendance of over 300, was held at the Academy of Metals and Mining from 28th - 30th September, inclusive, when 28 original Papers were presented by engineers and scientists from Poland, Czechoslovakia, Hungary and the U.S.S.R. The Papers covered a very wide field, including such subjects as "Researches in the Field of Sintered Metal Oxides"; "Volumetric Measurement Methods Applied to Investigation of Cutting Forces"; "Selected Problems of the Technology of Electro-impulse Machining of Metals"; and "High Productivity Turning and Milling".

After an address of welcome by Dr. Kaczmarek, the Director of the Institute, I was invited to give the greetings of the Institution to a Plenary Session.

On the final evening, an official dinner was given for the 27 foreign members of the Conference.

The next day the foreign visitors toured the Institute of Metal Cutting. Considerable advances had been made since my last visit with the Institution's Delegation in May 1958, notably in the field of ceramic tools and also in spark erosion and ultrasonic machining, all of which technologies have their separate departments.

Mrs. Pryor and I then left for three days' holiday at Zakopane in the Tatra Mountains, to be joined a day later by the rest of the visitors who had spent a day sightseeing in Cracow.

Mr. and Mrs. Pryor, with other visitors, at another stage of the tour.

Dr. Kaczmarek (third from left) Director of The Institute of Metal Cutting, with Mr. Pryor during his visit to the Institute.

The Conference concluded with another supper late on Sunday evening (3rd October), and my wife and I caught the sleeper to Warsaw to pay our respects to S.I.M.P. (The Polish Society of Mechanical Engineers) who were the Institution's hosts in 1958. President Brach and his wife, with several colleagues, gave us a farewell dinner before we left for home.

During the whole of the stay, whether in Cracow, Zakopane or Warsaw, the Poles exhibited their unsurpassed hospitality both publicly and privately. I was never without a private car, driver, and personal interpreter. During the time I was occupied at the Conference, Mrs. Pryor was also provided with her own interpreter and car for sightseeing and shopping.

An engineer from West Berlin, and I, were the only persons attending from our side of the Iron Curtain. This seemed to me a great pity, because not only is there much to be learnt from a technological point of view but such interchanges and personal contacts can do nothing but good in helping to resolve misunderstandings and misconceptions and relieving strains, in addition to making some contribution on the political side.

I hope that when such opportunities present themselves in future, many more of our members will take advantage of them.

# NEWS OF MEMBERS

**Mr. J. E. Burnett,** Member, has resigned from the Board of Helliwells Limited, and has also left the Tube Investment Group. He has now joined the Board of Flight Refuelling Limited, as Works Director.

**Dr. D. F. Galloway,** Member, Director of PERA, was recently elected World President of the International Institute of Production Engineering Research. He is the first Englishman to hold this office.

**Mr. W. Hirst,** Member, has taken up an appointment with Messrs. Tweedales & Smalley Limited, Castleton, Rochdale. Mr. Hirst has served on the Institution's Newcastle upon Tyne Section Committee.

**The Rt. Hon. the Earl of Halsbury,** Immediate Past President, has become a Scientific Consultant to the Research Organisation of Davy-United Ltd., Sheffield.

**Mr. F. G. Robinson,** Member, has relinquished his position as Technical Director of Luke Anthony Ltd., Camborne, to take up an appointment as General Manager at J. & J. Couch Ltd., St. Ives, Cornwall.

**Mr. D. A. Smith,** Member, has taken up a new appointment as Managing Director of Weir Valves Ltd., Glasgow.

**Mr. J. Ivan Yates,** Member, has now left Radiation Ltd. For the last 18 months he had been Managing Director of Radiation Group Export Sales Ltd.

**Mr. J. M. Ackland,** Associate Member, has recently relinquished his position with British Oxygen Gases Limited, and has taken up an appointment as Lecturer in Management Studies in the Department of Commerce, Social and Professional Studies at Hatfield Technical College.

**Mr. J. Bamford,** Associate Member, has been appointed Production Engineer at George Wilson Gas Meters Limited, Jarrow, Co. Durham.

**Mr. John M. Beattie,** Associate Member, has recently taken up an appointment with R.C.A. at Los Angeles, U.S.A.

**Mr. H. Beran,** Associate Member, has relinquished his position of Production Manager with Armco (Australia) Pty. Ltd., and has taken up an appointment as Works Manager with W. C. Stevens Pty. Ltd., Sydney, N.S.W.

**Mr. P. Griggs,** Associate Member, has now been appointed a Director of Velan Engineering Company Limited, Leicester.

**Mr. H. H. Hoch,** Associate Member, formerly Manufacturing Manager, Tool & Gauge Manufacturing Co., Sutton, Melbourne, has now joined Ferrocast Pty. Ltd., also of Melbourne.

**Mr. J. Isaacs,** Associate Member, has recently taken up a post as Chief Development Engineer with Messrs. Grieves and Thomas Ltd.

**Mr. F. E. Letchford,** Associate Member, has relinquished his position as Development Engineer at Morgan Crucible Co. Ltd., and has joined the U.K.A.E.A. at Springfields, Lancashire as Engineer II (Development Engineer).

**Mr. E. W. Loveland,** Associate Member, has relinquished his position as Manager, Aviation Division, of Walter Kidde & Co. of Canada Ltd., to become General Manager of Varney Inc., Miami, Florida, U.S.A.

**Mr. C. Needham,** Associate Member, has been appointed Director (Technical) of H. M. Ward & Co. Ltd. Mr. Needham has served the Company for many years.

**Flight-Lieut. S. J. Nowakowski,** Associate Member, is now Production Control Officer at the R.A.F. Maintenance Base, Seletar, Singapore.

**Mr. R. T. Pritchard,** Associate Member, has relinquished his appointment as Grade B Assistant Lecturer at the College of Further Education, Merthyr Tydfil, and is now Lecturer in Mechanical Engineering at Garretts Green Technical College, Birmingham.

**Mr. W. Moore,** Associate Member, is now with Reed Brothers (Engineering) Ltd., London, as the Technical and Development Engineer of the Rubber and Plastics Machinery Manufacturing Division.

**Mr. L. E. Rodwell,** Associate Member, has now left the College of Technology, Loughborough, in order to take up an appointment with the South-East Essex Technical College, Dagenham.

**Mr. L. J. Rose,** Associate Member, formerly Production Engineer at The Kenwood Manufacturing Company, is now Drawing Office Instructor at Queen Elizabeth's Training College for the Disabled, Leatherhead, Surrey.

**Mr. G. V. Shaw,** Associate Member, has relinquished his position as Deputy Factory Manager with Yorkshire Imperial Metals Ltd., Fyffe Works, Dundee to join Messrs. Geo. A. Mansill Ltd., Erdington, Birmingham, as General Manager.

**Mr. Gerald Smith,** Associate Member, has been appointed a Lecturer in the Department of Mechanical Engineering at the Harris College, Preston.

**Mr. M. H. Hancock,** Graduate, now serving his period of National Service with Her Majesty's Forces, was commissioned as an officer of R.E.M.E. at the Commissioning Parade at Aldershot on 5th November last.

# Journal Contents

## Volume 38, 1959

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1959/1960

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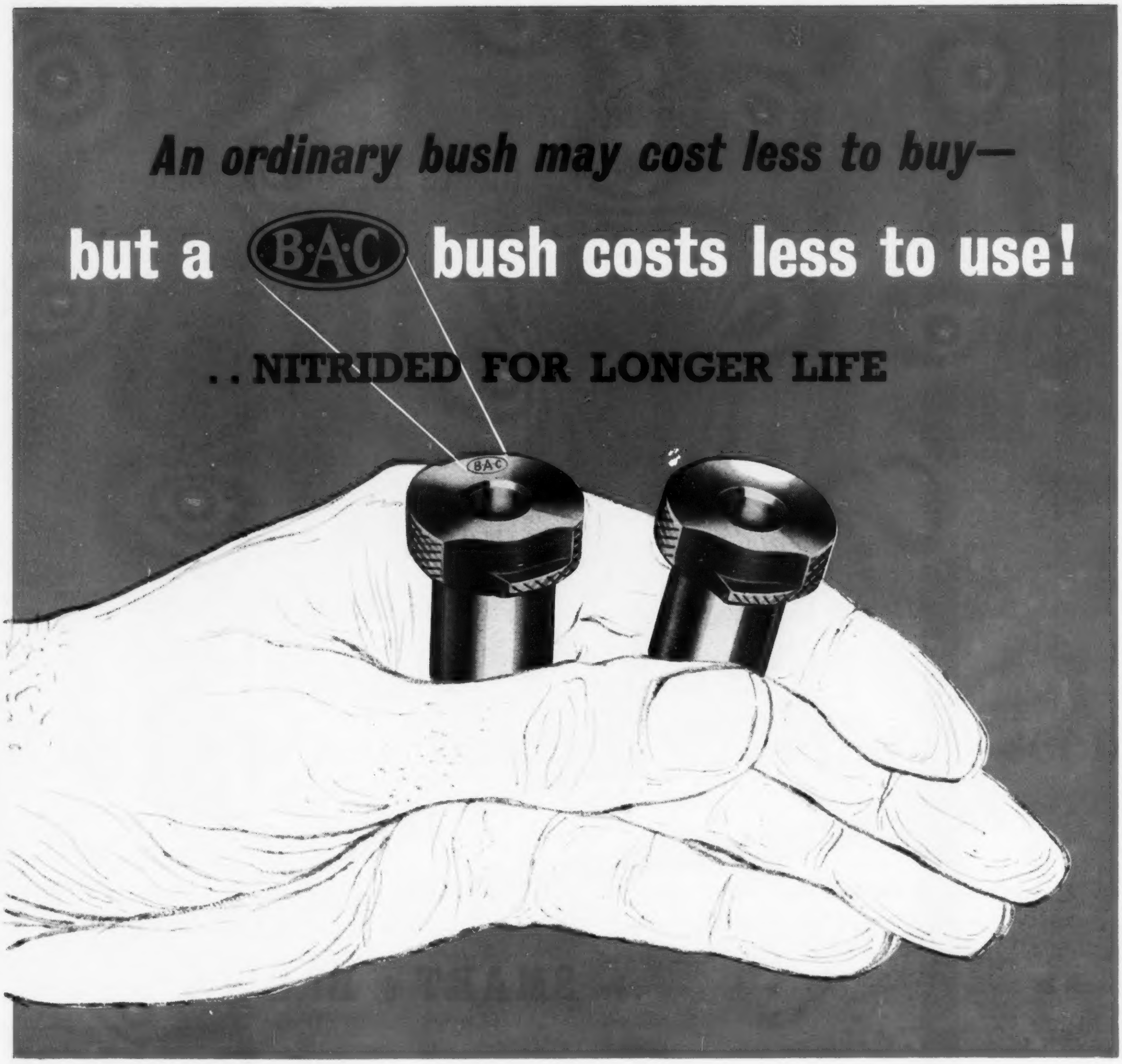
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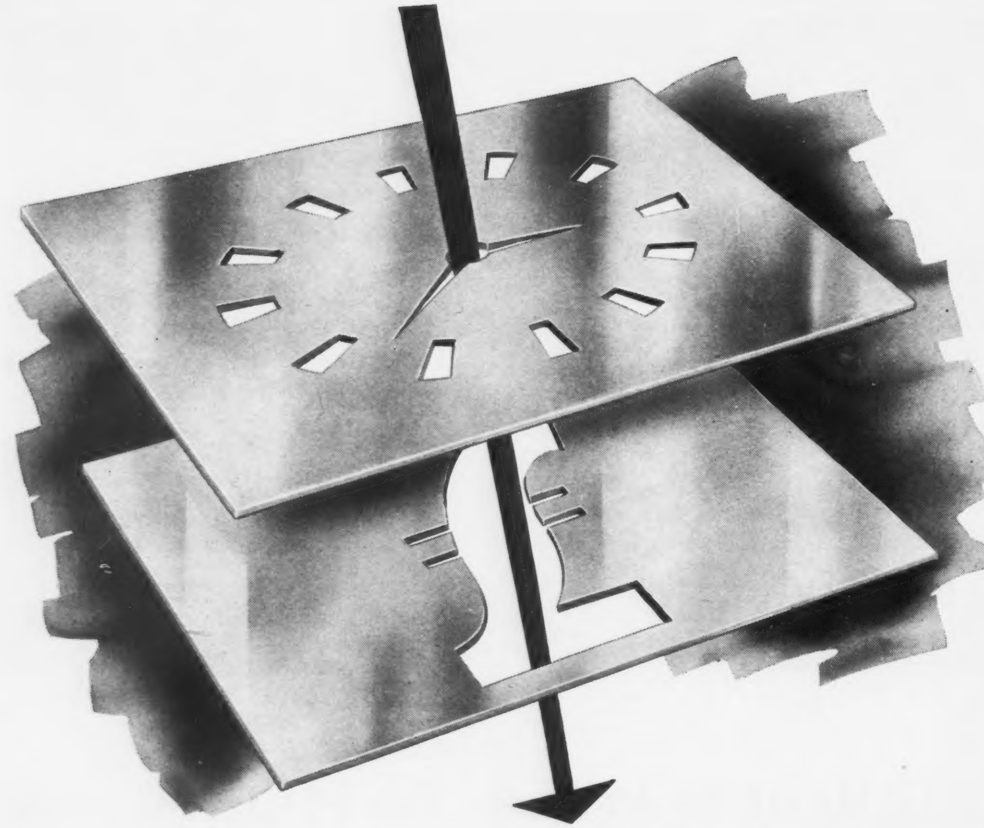

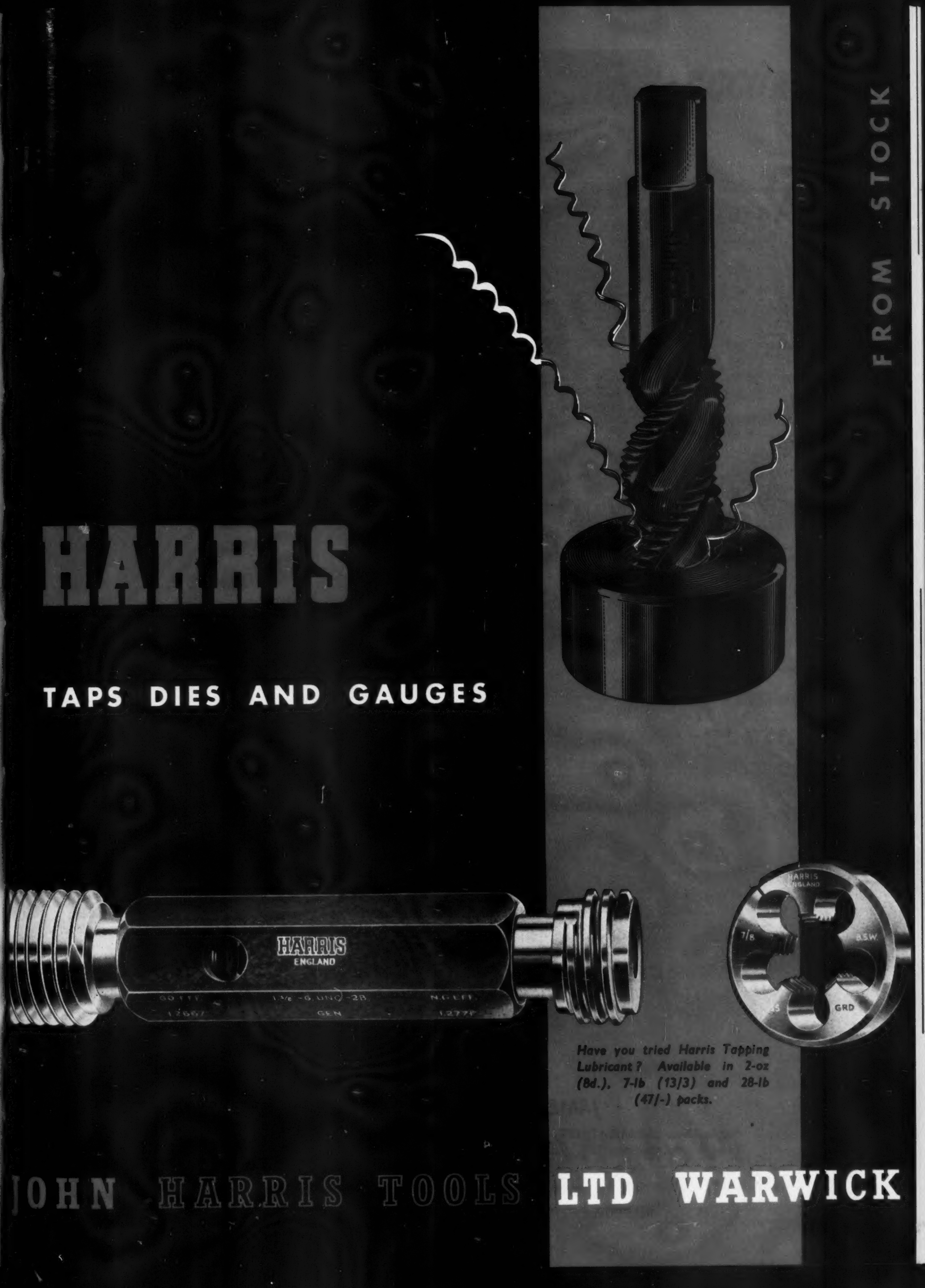
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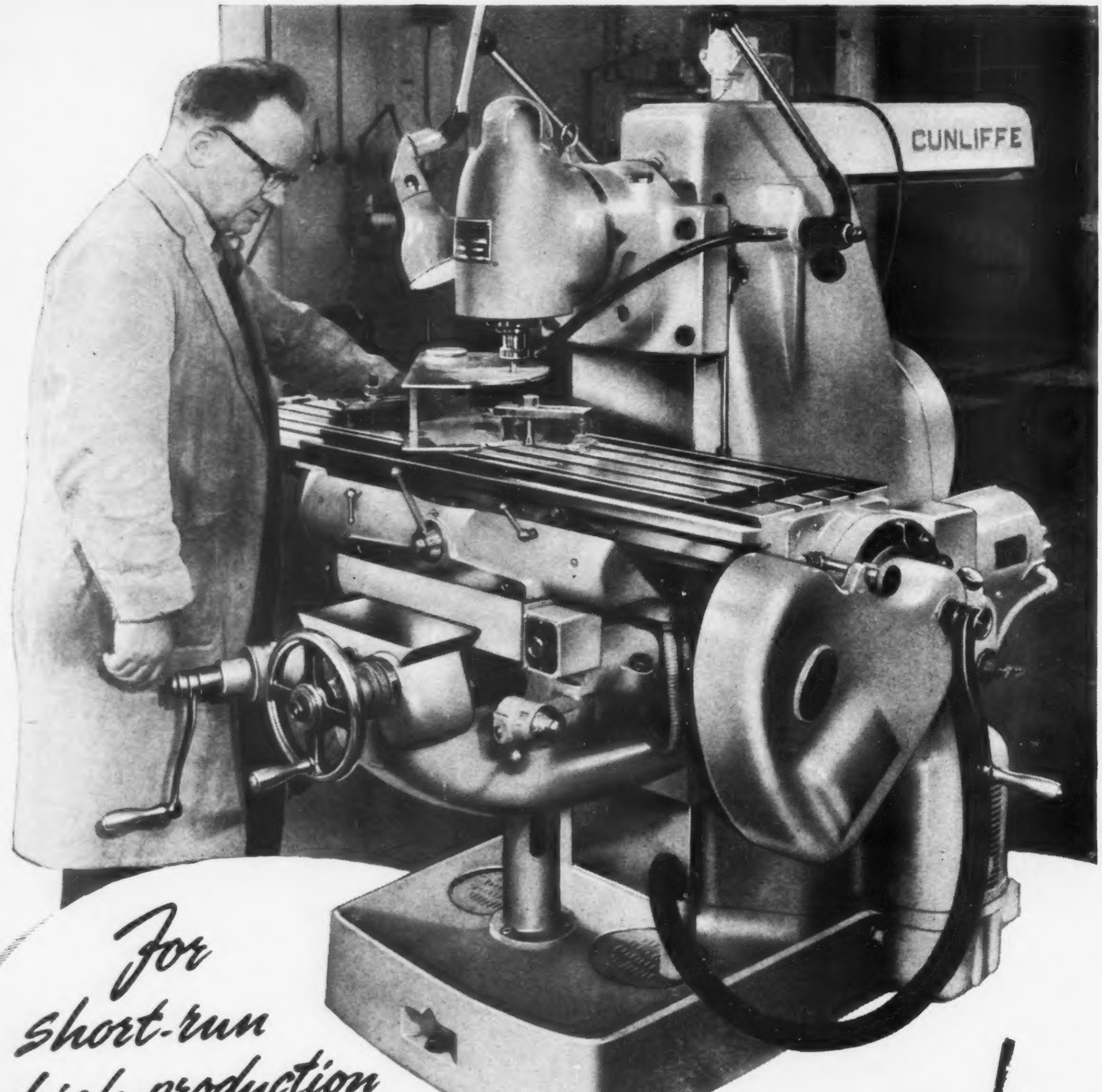
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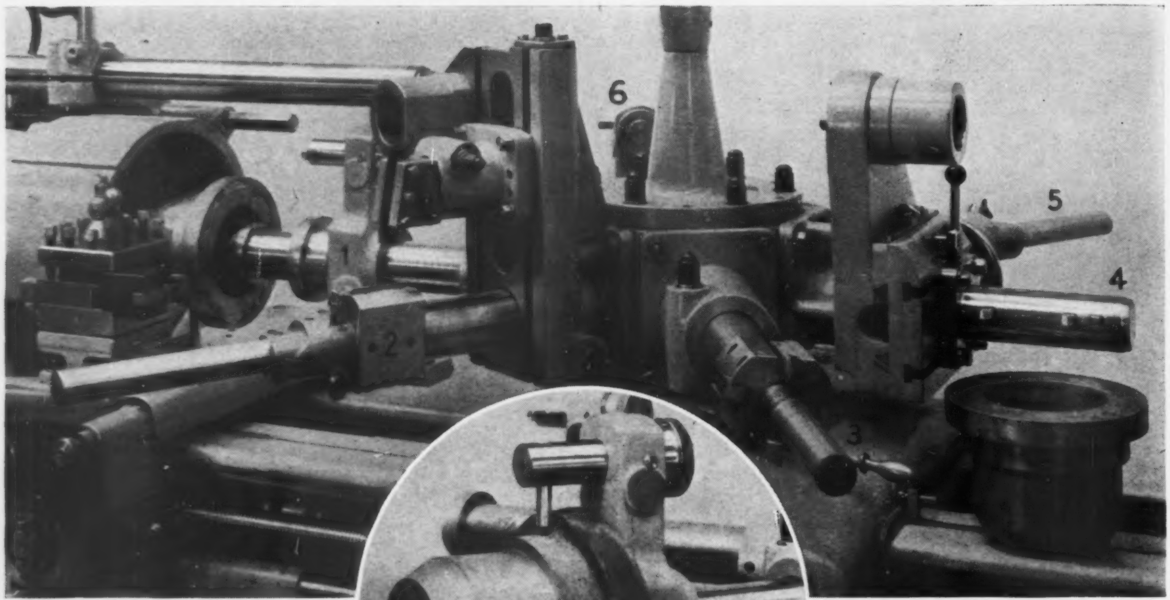
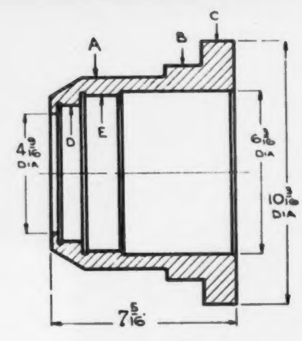



**Ward**

## No. 8 TURRET LATHE

FITTED WITH 15in TUDOR 3-JAW CHUCK

| DESCRIPTION OF OPERATION | Tool Position | | Spindle Speed R.P.M. | Surface Speed Ft. per Min. | Feed Cuts per inch |
|---|---|---|---|---|---|
| | Hex. Turret | Cross-slide | | | |
| 1. Chuck on A (using Loading Attachment) | 1 | — | — | — | — |
| 2. Rough Face and Rough Turn C (1st cut) | — | Front 1 | 85 | 235 | 48 |
| Rough Bore $6\frac{3}{16}$ and $4\frac{9}{16}$ and Rough Turn C | 2 | — | 85 | 230 | 70 |
| 3. Rough Bore D and E | 3 | — | 85 | 133 | 70 |
| Rough Turn B and Face Back of Flange | — | Front 2 | 85 | 225 | 70 |
| 4. Undercut and Chamfer Bores (Recessing Toolholder) | 4 | — | 85 | 133 | Hand |
| 5. Microbore D, E and $6\frac{3}{16}$ dias. | 5 | — | 175 | 285 | 98 |
| Finish Turn C | — | Front 3 | 175 | 465 | 70 |
| Finish Double Face Flange | — | Front 4 | 175 | 465 | 70 |
| 6. Remove Part from Chuck (using Unloading Attachment) | 6 | — | — | — | — |

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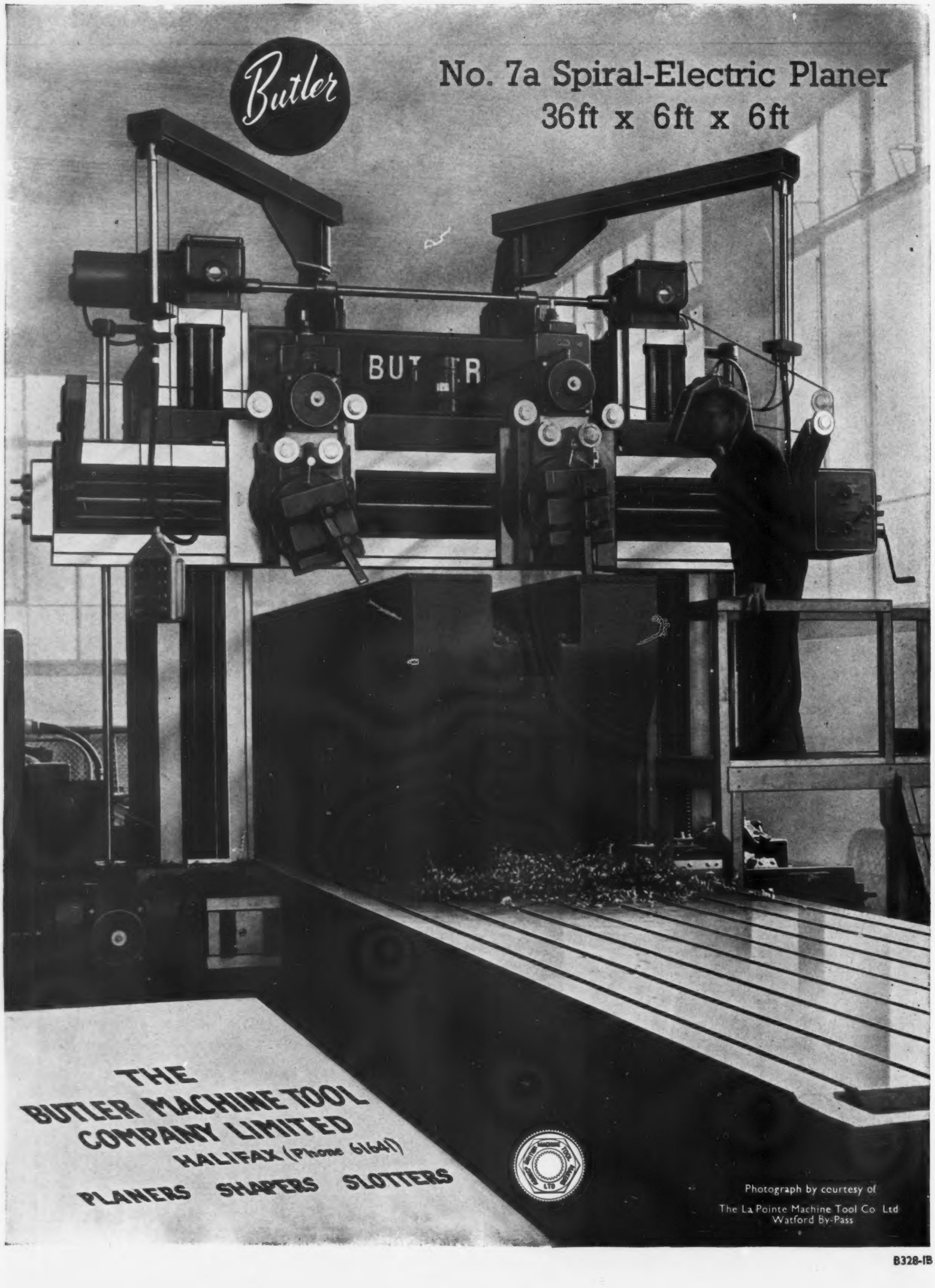
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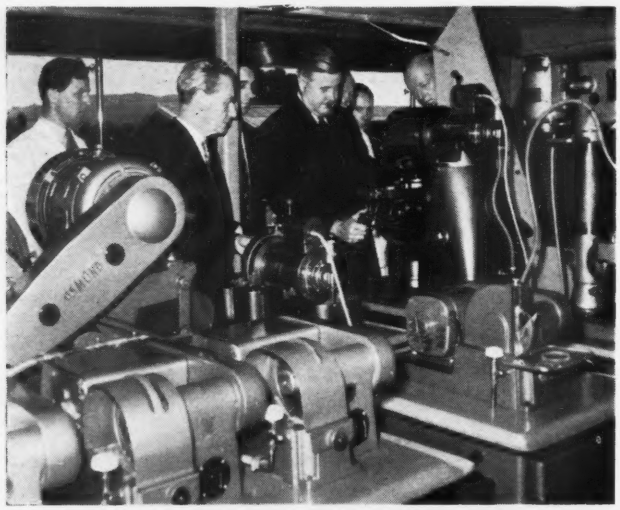



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*Electrical Aids in Industry* *Data Sheet* **No. 8**

# Light-Sensitive Cells

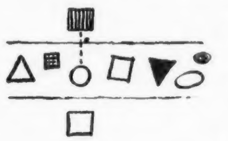
*What are light-sensitive cells?* They are devices which can sense and measure changes in the level of light or, in some cases, respond to the quality of light falling on them. There are various types of cell and each has its particular field of use. One of the best known is the photo-electric cell.

*What can light-sensitive cells do?* A change in the amount of light falling on the cell can cause a switch, relay or counter to operate. Alternatively, the direct indication of the light intensity can often allow some other factor to be determined and, if required, controlled. They are reliable and require little maintenance. Careful installation, as with all types of equipment, gives a good reward.

*How can they be used?* These cells have many applications in industry, for controlling processes, for inspection and measurement, for sorting material and for safety purposes:

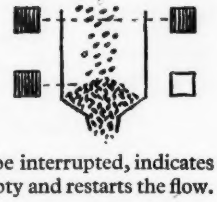
### *Counting*

Where objects on a conveyor belt are too soft or light to operate a direct mechanical counting device, where they are too delicate or freshly painted to sustain physical contact or where the articles vary in size, a light-sensitive cell can be used. This counts the objects by interruption of an appropriately sited beam of light.



### *Hopper or Tank Level Control*

Many forms of feed can be accurately controlled by light cells. One important one is for controlling the input to a hopper of fluid solids such as sand or peas. Here, two horizontal light beams are required: the upper, when interrupted, indicates that the hopper is full and stops the supply; the lower, when it ceases to be interrupted, indicates that the hopper is nearly empty and restarts the flow.



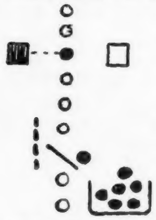
### *Package Content*

The level of powder in packages can be checked with light cells. The cell is so positioned that when the

powder is up to the required level, the light reflected from the surface of the powder is picked up by the cell and causes the carton to be accepted. If not, it is rejected.

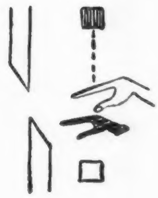
### *Colour Sorting*

The quality of many articles can be gauged by their colour—seeds and nut kernels, for instance. The objects are fed into a tube by means of a vibrator pan and fall into the beams of three equally spaced light cells which scan them from all sides. If the object is acceptable it falls into a chute carrying it to one conveyor; if its colour is bad it is deflected as a reject.



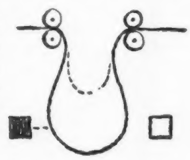
### *Guillotine Guard*

Light cells for guarding a guillotine or power press should be used only as a supplement to a mechanical guard or where the latter is impracticable. The interruption of a curtain of light by a hand stops the machine instantaneously.



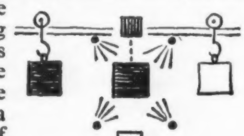
### *Press Feeding*

Where the rate of feed of strip metal must be suited to a varying speed of acceptance by a press, a loop of the strip is allowed to sag between the feed and the press. When the loop reaches a predetermined depth a light beam is interrupted and the slack is taken up.



### *Processing Objects on the Move*

Many articles are processed while on a conveyor line. For instance, where articles are to be sprayed while on the conveyor, the paint saved by stopping the gun between articles will make the device worthwhile. The same principle applies in a bakery to the spraying of baking tins with fat.



### *Automatic Door Opening and Closing*

Doors can be caused to open or close by the interruption of a beam of light. This has its uses in such cases as control of doors on a heating oven or for the passage of vehicles in a factory. This is effected by a light beam on the side from which the approach is made (in many cases, both). When the approach beam is interrupted it opens the door which closes again after a given time interval.

For further information, get in touch with your Electricity Board or write direct to the Electrical Development Association.

An excellent series of reference books are available (8/6 or 9/- post free) on electricity and productivity — "Higher Productivity" is an example. E.D.A. also have available on free loan a series of films on the industrial uses of electricity. Ask for a catalogue.

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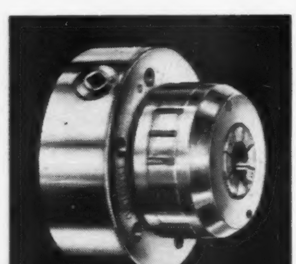

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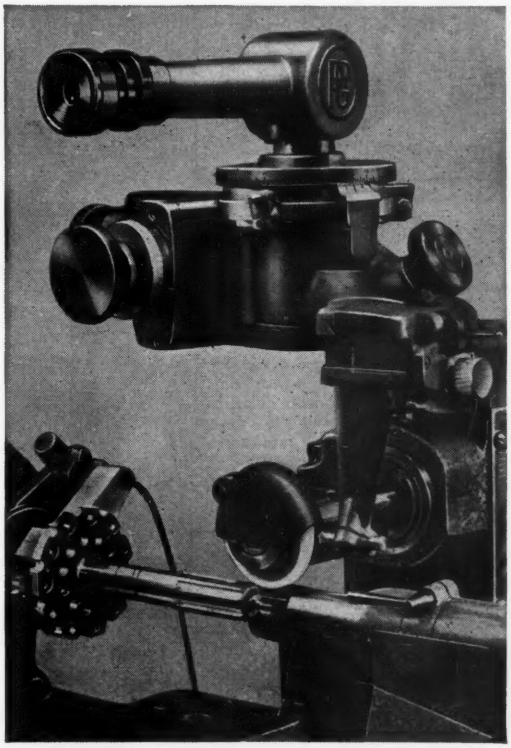

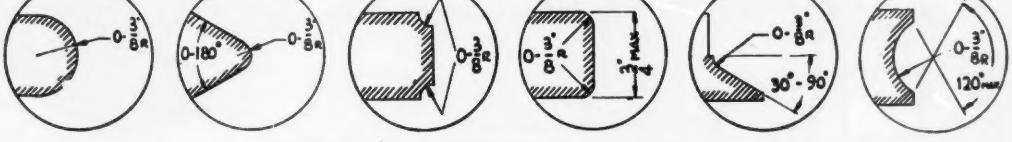


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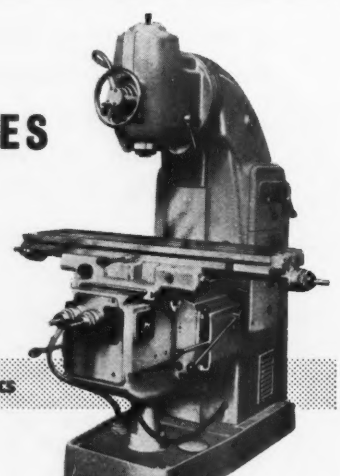
- 18 table feeds 0.65 - 15 in./min. or 0.93 - 21.5 in./min.
- 5 h.p. motor
- Backlash eliminator standard equipment



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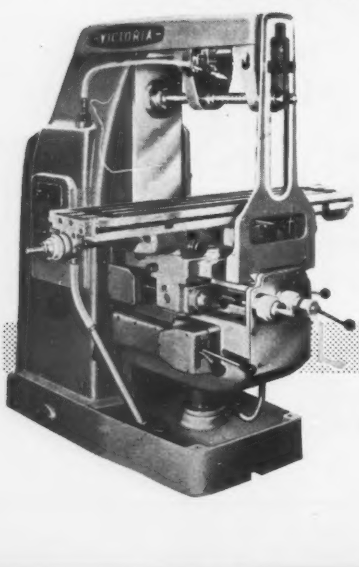


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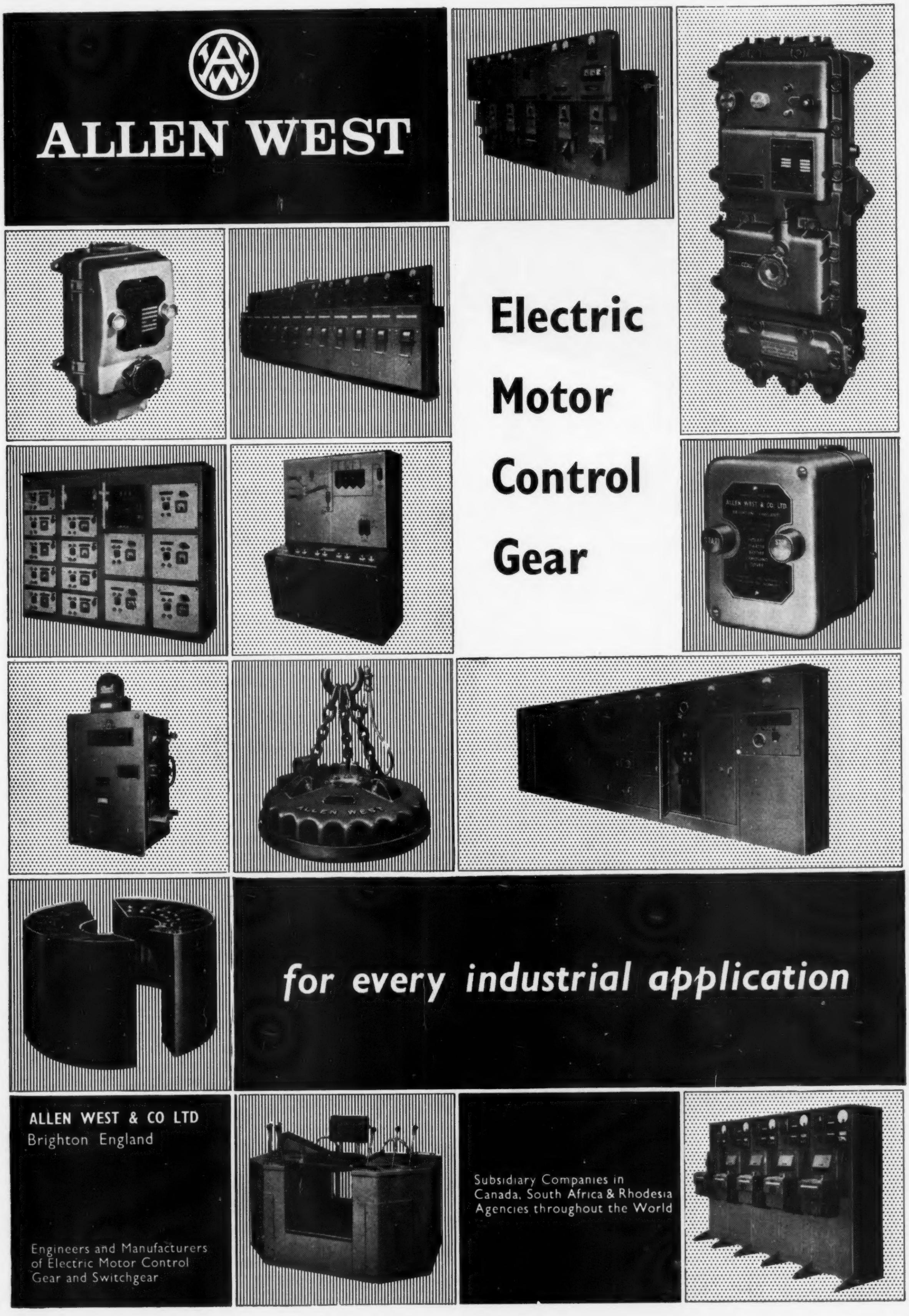
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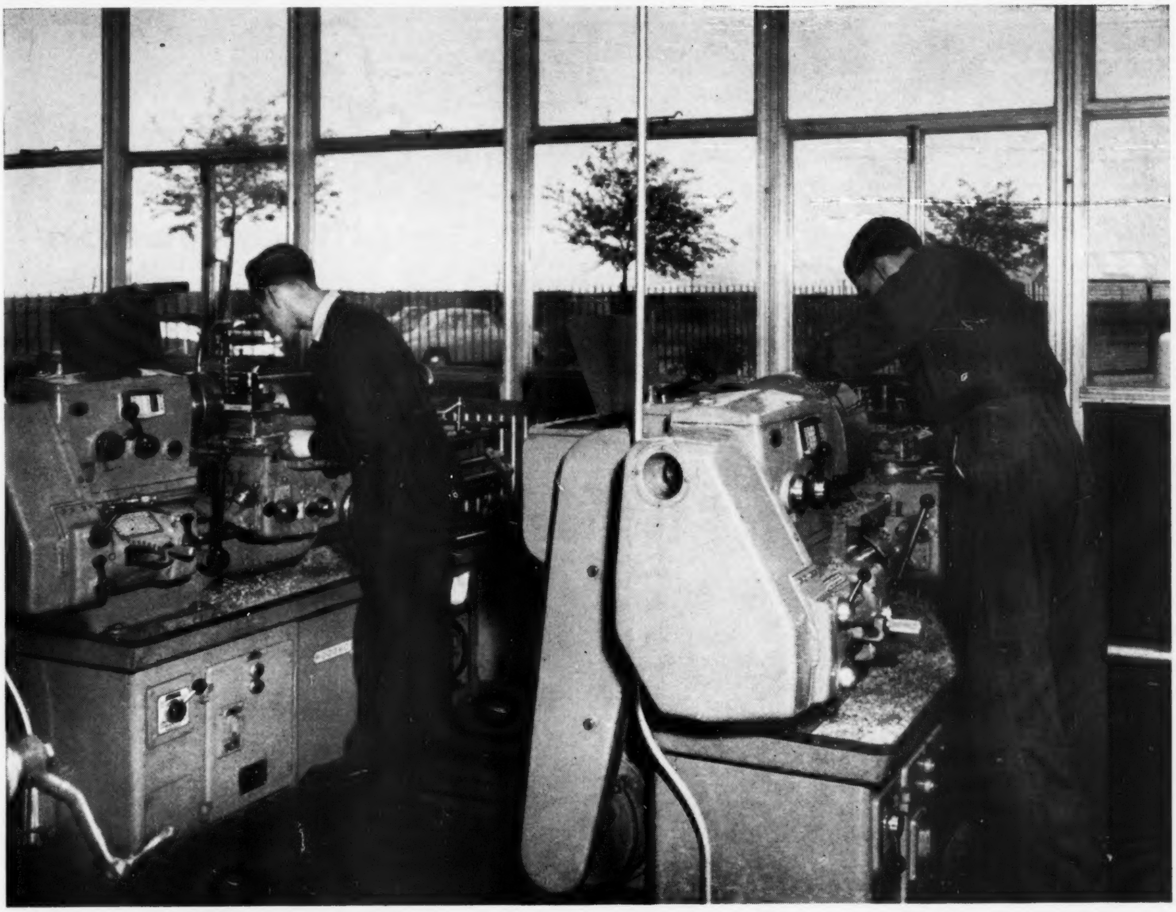

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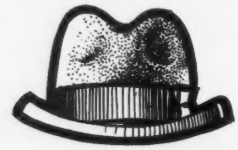
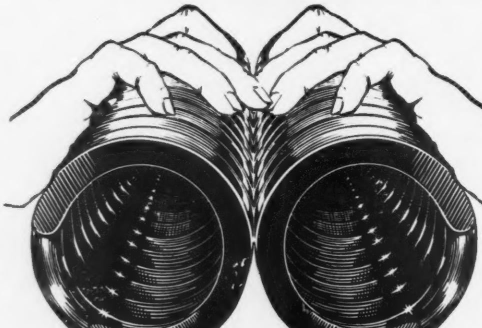


# Looking in the right direction



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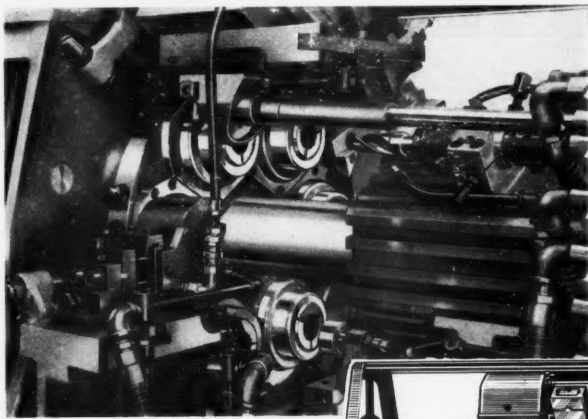
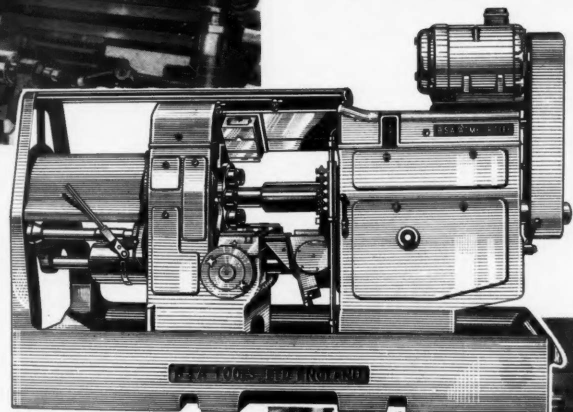


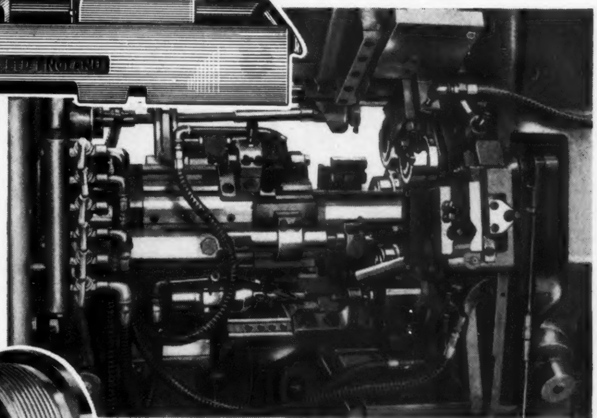
*Tooling for the subject component showing the thread-rolling box (position 2) and the polygon box for generating the flats (position 3)*

# B·S·A

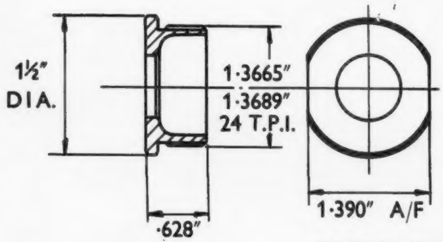
# ACME - GRIDLEY



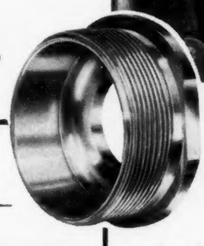
$1\frac{5}{8}$ 6-spindle automatic bar machine

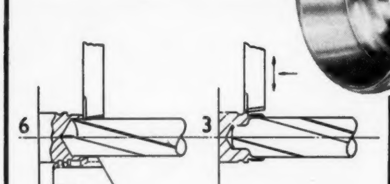


*Showing the burnishing tool on the main tool slide at position 5.*




**STEEL**






**16·25 SECS**

**6:** feed stock, form, undercut thread dia., rough O.D., rough bore, face to length.

**1:** rough drill, finish turn thread diameter.

**2:** roll thread.

**3:** generate flats, semi-finish bores.

**4:** bore, finish-machine ball track, breakdown for part-off.

**5:** burnish ball track, part-off.

Spindles speed: 471 r.p.m.
Cutting speed: 184 f.p.m.

TRADE MARKS
B·S·A TOOLS DIVISION

MAKERS B. S. A. TOOLS LTD · BIRMINGHAM 33 · ENGLAND

*SOLE AGENTS U.K. BURTON GRIFFITHS & CO. LTD., MACKADOWN LANE, BIRMINGHAM 33. STECHFORD 3071*

## INDEX TO ADVERTISEMENTS

Please note that all advertisement pages are prefixed with the letter "A".



All communications regarding advertisements should be addressed to the Advertising Managers, T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2. Telephone: HOLborn 4743.
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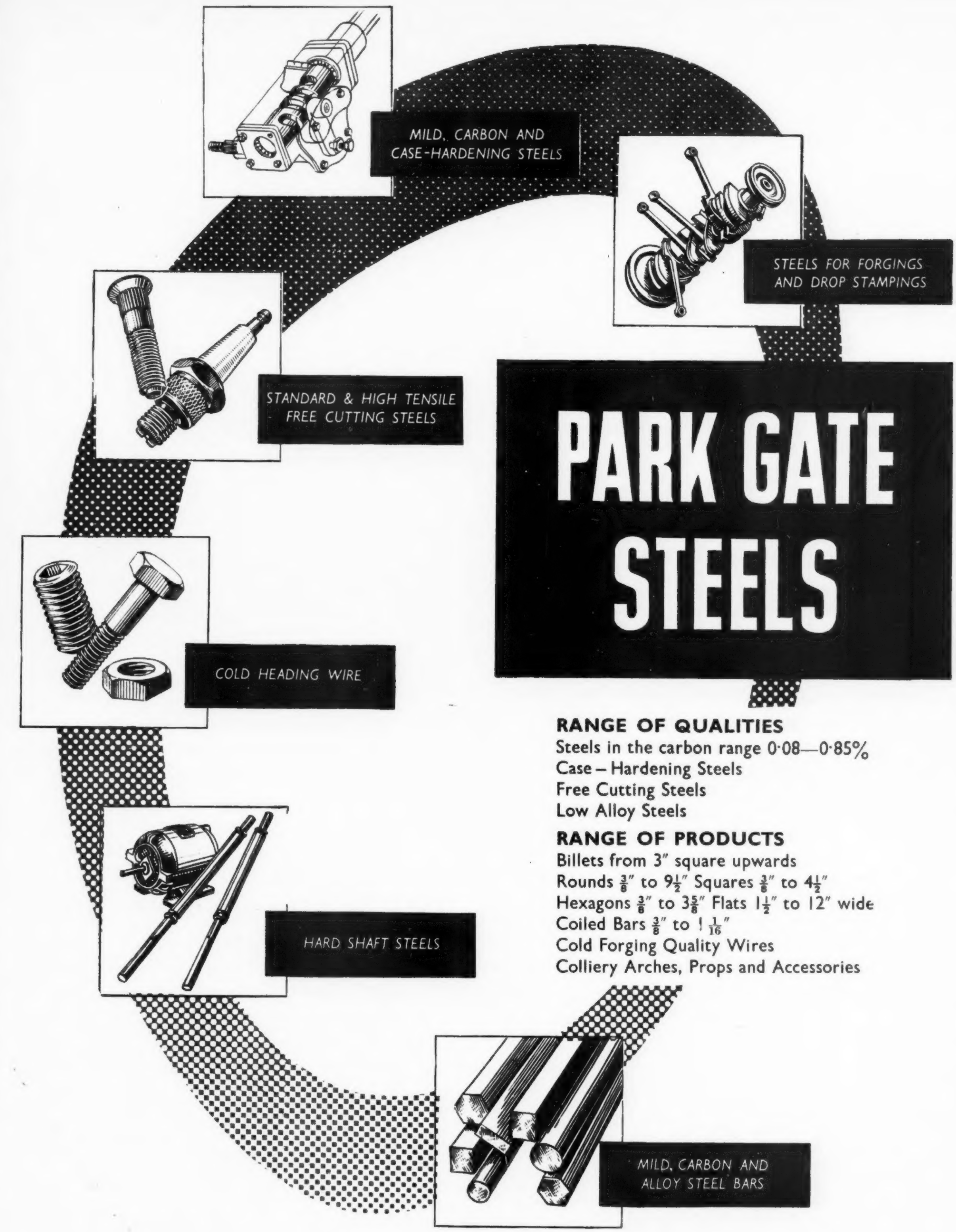
MILD, CARBON AND CASE-HARDENING STEELS
STEELS FOR FORGINGS AND DROP STAMPINGS
STANDARD & HIGH TENSILE FREE CUTTING STEELS
COLD HEADING WIRE
HARD SHAFT STEELS
MILD, CARBON AND ALLOY STEEL BARS
PARK GATE STEELS
RANGE OF QUALITIES
Steels in the carbon range 0·08—0·85%
Case – Hardening Steels
Free Cutting Steels
Low Alloy Steels
RANGE OF PRODUCTS
Billets from 3" square upwards
Rounds $\frac{3}{8}$" to $9\frac{1}{2}$" Squares $\frac{3}{8}$" to $4\frac{1}{2}$"
Hexagons $\frac{3}{8}$" to $3\frac{5}{8}$" Flats $1\frac{1}{2}$" to 12" wide
Coiled Bars $\frac{3}{8}$" to $1\frac{1}{16}$"
Cold Forging Quality Wires
Colliery Arches, Props and Accessories
THE PARK GATE IRON & STEEL COMPANY LIMITED ROTHERHAM
A TI Company
TELEPHONE: ROTHERHAM 2141 (10 lines) TELEGRAMS: YORKSHIRE, PARKGATE, YORKS. TELEX 5414